ELECTRICAL REVIEW

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VIEWS, NEWS AND INTERVIEWS.

A gentlemen, who has been very closely associated with Edison, thus describes his method of work: "A line of investigation is selected and a series of experiments begun. The results are carried in both the positive and negative direction to their fullest extent; that is, the machine or device is worked upon in one way until it is as fine and perfect as it can then be made. Then it is carried as far in the opposite direction; that is, by degrees it is made as inefficient and poor as it possibly can be. Then Mr. Edison asks himself where is the point at which Tom, Dick and Harry can understand this thing, and what are its most prominent and valuable commercial aspects. Then the positive and negative results are averaged and the commercial machine produced. In this way a machine such as the average man can understand and operate is produced, while there is left in reserve the balance above the average on the positive side of the experiments which will permit the machine to be used for expert work if such is ever desired."

A gentleman who professes to know informs me that Professor Edison gets many of his ideas for practical inventions from the wild flights of imagination taken by writers of fiction. This will be pleasing news to a good many people who have long been wondering what on earth the United States Weather Bureau is good for.—*Detroit Free Press.*

A firm of Boston brokers gives the following information in a recent circular letter:

"There has been some little selling of Bell telephone lately, perhaps partially due to the stringency of the money market, and possibly somewhat to an apprehension on the part of timid holders that, at the expiration of the patents competition will be attempted. We have taken considerable pains to inform ourselves on the actual situation, and have come to the conclusion that while competition may be attempted it can make very little headway, and very slight inroads on the company's earning powers. In addition to being sole owners of the Long Distance Telephone Company, the American Bell Telephone Company practically controls nearly every telephone company in the United States. They are also large stockholders in the Canadian Telephone Company and in the Western Electric Company, of Chicago (the largest manufacturers of electrical apparatus, etc., in the country, if not in the world), and from all of these companies the revenues will eventually be very large."

A Western poet has ejected the following from his system. It is probably one of the effects of Farmer Dunn's last batch of hot weather. The Cairo, Ill., *Bulletin*, must be held accountable for inflicting these lines upon a patient and perspiring public:

"The electric car rolls gayly down the handsome avenue, the motorneer looks straight ahead, oblivious of you. You can't catch the conductor's eye, he clearly means you sha'n't; you want to whistle, but you are a woman, and you can't. You shake your parasol in vain, there's nothing else to do, and then you stand and watch the car roll down the avenue."

Patent lawyers at least can afford to keep cool these hot days. Business is brisk with them now.

A correspondent writes that one of the causes of the constant turmoil going on in the little island of Hayti is that there is not a telegraph line on the island.

If you are passing through the City Hall Park late at night you will see a number of men down on their hands and knees in the grass crawling about. They are fishermen hunting for the big worms called "night walkers," because they crawl out of the ground at night to investigate the arc lights with which the Park is lit. The worms make good bait.

A Western exchange tells us that razors and gold pens should be laid aside from time to time, as they need a rest from work just as much as men. The reason for this is gravely explained as follows:

"Some sort of electromagnetic action takes place in the metal, which has a tendency to bring into parallel lines all the particles, and in that condition a razor cannot be made to hold edge, and a pen is equally refractory.

"If the razor is laid aside for a time the particles of metal gradually resume a more or less confused arrangement and the razor takes on and retains a keen edge.

"It is the same way with a gold pen. Now, if when one of my pens gets to acting bad I lay it aside for a month or so it will be all right again. That's why I said that pen was tired and wanted a rest."

It is said that a number of Philadelphia small boys have organized themselves into a society, the object of which is to form the members in a circle about an electric light pole to secure a shock. By some means or other they discovered that if one of the spikes on the pole was touched a slight shock could be had; so now two boys each take a piece of wire and hooking the wires over the spike on the pole a circle is formed, and everybody is shocked to his heart's content. It is expected that a number of funerals will be announced in the near future.

Increase of Capital Stock.

The electrical house of Alexander, Barney & Chapin, New York, has voted to increase its capital stock to an amount not to exceed $200,000. Increase of business is given as the reason for this progressive step, the company reporting a large and growing trade at the present time, although this is generally the dull season of the year.

Obituary.

Thomas Byrnes, local manager of the Jenny Electric Light Company at Indianapolis, died at Evansville, Ind., last week.

Thomas M. J. Hannon, a member of the New York Telegraph Club, and well known in telegraph circles, died June 25, after a short illness, aged 29, at the residence of his brother in New York city.

Prof. William Edward Weber, the well known electrician and physicist, died June 24, at Goettingen, Hanover. Professor Weber was born October 24, 1804, at Wittemberg, Saxony, and in 1825 commenced to make a stir in the electrical world. From that time, or dating from the publication of his "Theory of the Waves," Professor Weber was a central figure in all matters pertaining to electricity and magnetism. In 1845 he was appointed professor of physics at Leipzig. Professor Weber and his associate, Professor Gauss, were instrumental in the establishment of several magnetic observatories in various parts of the world, and the results of their researches are contained in several valuable works which they published together.

Electrocution at Sing Sing.

As we go to press information is telegraphed from Sing Sing, N. Y., that the four murderers confined there were executed by means of electricity. The work was done secretly, about 5 A. M., Tuesday.

PERSONAL.

Henry Villard arrived in New York from Bremen, July 1.

Prince George of Greece visited Edison's laboratory last week.

Prof. Sidney A. Short, of Cleveland, last week made a brief visit to the Thomson-Houston factories at Lynn, Mass.

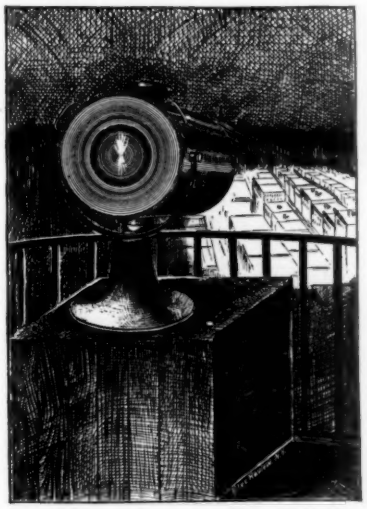
Frederick-the-First Degenhardt, of Chicago, favored New York with his royal presence several days last week.

Mr. Ira W. Henry, formerly cable electrician for the East River Electric Light Company, has accepted the position of general electrician for the Bishop Gutta Percha Company of this city.

Mr. W. R. B. Willcox, who has charge of the electric heating department of the Electric Merchandise Company, Chicago, was in New York last week conferring with Mr. S. Dana Greene, the consulting electrician of the company.

Mr. Harvey N. Shepard, formerly assistant attorney-general of Massachusetts, and Mr. Eugene B. Hagar, formerly assistant city solicitor of Boston, have formed a copartnership for the practice of the law, and have taken offices in the new exchange building, No. 53 State street, Boston.

Mr. N. S. Possons, formerly superintendent for the Brush Electric Company, has been engaged by the Eureka Tempered Copper Company, North East, Pa., in the capacity of general sales agent and traveling representative. His large experience in electrical and mechanical matters will make him particularly valuable to the Eureka Company.



SCOTT'S SEARCH-LIGHT ON THE PULITZER BUILDING, NEW YORK.

A High-Up Search-Light.

An electric search-light has been placed on top of the high Pulitzer building, New York, a view of which appears on this page. It will undoubtedly furnish much entertainment to privileged visitors to the highest accessible point of this notable building.

Electrical Measurement of Power.

A at meeting of the British Physical Society, June 12, Professor Ayrton read a paper on "Alternate Current and Potential Difference Analogies in the Methods of Measuring Power," by himself and Dr. Sumpner.

In a paper read before the society in March last, the authors pointed out that for every method of measuring power in which readings of volts and amperes were taken, other methods in which amperes were read instead of volts, and volts instead of amperes, could be devised. More recently Dr. Fleming had,

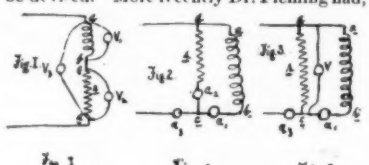


Fig 1 Fig 2 Fig 3.

by transformation of formula given by the authors in a communication made to the Royal Society on the measurement of power by these voltmeters, given the analogue in which three ammeters were employed. The two arrangements are represented in Figs. 1 and 2, whilst Fig. 3 shows a modification of Dr. Fleming's method (Fig. 2) in which the current in the non-inductive resistance r is measured by the aid of a voltmeter V across its terminals. This obviates the necessity of putting an electromagnetic instrument in what should be a non-inductive circuit. The formula for the mean watts spent in the circuit a b, Figs. 1 and 2, are

$$W = \frac{1}{2r}\left(V_3^2 - V_1^2 - V_2^2\right) \text{ and}$$

$$W = \frac{r}{2}\left(A_3^2 - A_1^2 - A_2^2\right), \text{ respectively.}$$

Mr. Blakesley's method of measuring power by a split dynamometer was shown to be analogous to the original electrometer method in which the difference of two readings was proportional to the power, and Blondlot and Currie's double electrometer method was shown to be the analogue of the ordinary wattmeter. The wattmeter was defective in the fact that a solenoidal coil was inserted in a nominally non-inductive circuit. The error thus introduced, is, as was shown by one of the authors some years ago, expressed by the formula

$$\frac{\text{apparent watts}}{\text{true watts}} = \frac{1 + \tan\Theta \tan\phi}{1 + \tan^2\phi}$$

where Θ is the phase angle between the current and E. M. F. in the circuit in which the power is to be measured, and ϕ the phase angle for the approximately non-inductive circuit. It is now proved that the same formula expresses the error in any of the methods where resistances not wholly non-inductive are used.

As is well known, Mr. Blakesley has applied his split dynamometer to the measurement of phase differences between two currents; and an analogous method of finding the phase difference between two potential differences is described in the paper. In this method a high resistance split dynamometer, such as suggested by Mr Remington for measuring power is employed. Blondlot and Currie's double electrometer could also be used for the same purpose. Numerous diagrams illustrating the various analogies accompany the paper.

Prof. S. P. Thompson enquired whether hot-wire voltmeters could be employed to measure the various potential differences without introducing error.

In reply, Professor Ayrton said that although no great error was introduced by the self-induction of these instruments, yet the fact that they required considerable current was a disadvantage, and as these currents were not always in the same phase as those in other circuits, troublesome corrections were sometimes necessary. Electrostatic instruments were preferable.

Quick Work of the Baxter Electric Motor Company.

On the eighth of June the Baxter Electric Motor Company shipped three trucks, with motors attached, to Beatrice, Neb., and on the twelfth they sent a generator of 80 horse-power; at the same time an expert electrician was despatched from the works to put the road in operation, including the erection of the power house. June 30 the following telegram was received by the company: "Second car started June 27, 11.30 P.M.; 2,500 passengers Sunday without a hitch of any kind."

The Baxter Company report a large number of orders for cars and motors throughout the South and West, and are shipping the goods as fast as they are finished. The company's electric motor cars are now running in Richmond on the Richmond and Manchester Street Railway Co.; Dayton and Cleveland, O.; Chicago, Ill.; Washington, D. C.; and many other places.

The Agricultural and Mechanical College of Alabama.

This college, situated at Auburn, Ala., has decided to establish an electrical department next Fall. Prof. A. F. McKissick has been appointed professor in charge. This college is the leading mechanical college in the South, and is situated in the iron regions of Alabama. Prof. McKissick graduated at the South Carolina University with the degrees of B. S. and A. M., in 1889. He was superintendent of the Columbia Electric Light Company for 18 months, and then resigned to take the course in electrical engineering at Cornell. The adoption of this course by the Agricultural and Mechanical College of Alabama is evidence of true progress, and will result in great good to the young men of the South.

LITERARY.

"Catalogue of the Pratt Institute, Brooklyn, 1891-92" has been received.

We have received Mr. Erastus Wiman's address to the New York Board of Aldermen on "The Removal of Elevated Tracks From Battery Park."

The July *St. Nicholas* has a rich abundance of the short and bright articles which children are so fond of reading, there being 30 items in the table of contents.

The Popular Science Monthly is now publishing a series of profusely illustrated articles on "The Development of American Industries Since the Time of Columbus."

A portrait of Horace Greeley forms the frontispiece of *The Century* for July to accompany a hitherto unpublished address by Mr. Greeley on Abraham Lincoln, which, coming after the Hay and Nicolay history, and Mr. Schurz's review of the same, will be read with particular interest, not lessened by the knowledge of the peculiar relations which existed between Lincoln and Greeley. The address was written in or about 1868, and is printed from the original manuscript.

If it is true that "not one American in a hundred knows how to take a vacation" the July number of *The Ladies' Home Journal* has a distinct educational value, for it quite overflows with new and good counsel for summerings; beside the hints for "The Mother in the Country," to which many clever women have contributed, there are helpful words from Mrs. Margaret Bottome and Dr. Talmage; while in the bright page for "The Woman in the City" the lot of the stay-at-home is shown to be not so dreadful, after all.

A Study of Electric Shadows.

What a splendid study in chiaroscuro is afforded by the electric light amid foliage? Why don't the artists paint it or attempt to do it? Stand in the shade yourself, and let the light sift toward you and past you through the foliage of a tree-top, shattering itself softly to pieces against the tree-trunks, or lighting up exquisite fairy dells in the shrubbery. What diamond splashings and spatterings, what arabesques and silhouettes of densest black—so opaque, so sharply defined, that you can scarcely believe your reason against your sense of sight, and regard them as only the fretted lace-work shadows of leaves, the mere negation of light. It took the keen eye of a Ruskin to teach us that a shadow in sunlight is one of the sharpest outlines in nature; but any one can see the sharp-cut definition of these leaves and twigs. Northern sunlight is too universally diffused to throw into very striking relief any particular shadow, but these lamps have the advantage of darkness all around them. Hence the splendor of their light, recalling the description in Tennyson's Recollections of the "Arabian Nights":

> "The fourscore windows all alight
> As with the quintessence of flame,
> A million tapers flaring bright
> From twisted silvers look'd to shame
> The hollow-vaulted dark."

Allusion was made to the artists. But the impressionists must not understand themselves to be meant. Rather is the astral light of the electric lamp and its phenomena a theme for a Flemish pencil of minutest touch; one that would paint as Tennyson paints in the poem above quoted—the damask-work and deep inlay of braided flowers on the moonlit sward, the colored shells of the walks, the flints beneath the shallop's prow, the crimson flowers in fluted vase, and the engarlanded and diapered cloth of gold down-flowing from the good Alraschid's throne. You don't find any "impressionist" painting in Titian or Raphael or Veronese—nor in nature, either, at close range.—*Boston Transcript.*

The Intense Brilliancy of Lightning.

The following is abstracted from Caillard's book on "Electricity," published by D. Appleton & Company, New York:

"One consequence of the short duration of lightning is an apparent diminution of its brilliancy. It has been proved that light cannot produce its full effect on the eye unless it remains at least as long as one-tenth of a second; but lightning lasts only the ten-thousandth part of a second, and it follows from this that we see it 100,000 times less bright than it really is. When we recollect that even thus diminished its brilliancy is such as to cause temporary blindness if too closely watched, we may feel grateful that we cannot see it in its true vividness, for any human powers of vision would be too weak to bear such a sudden and overwhelming illumination."

I Christen Thee, "Autogram."

Miss Kate Field has several times turned her brilliant mind to matters electrical. An interesting conflict of mental scintillations and electric sparks is always the result—a regular short circuit of mental currents, as it were. Here is Miss Field's latest, which appeared in *Kate Field's Washington.*

"Electric shocks to one's mentality are becoming positively alarming. On the longest day of this year W. E. Gump, evidently misnamed, who is the general manager of the Writing Telegraph Company, of New York, sent autograph messages by telegraph wire from Chicago to New York. So I suppose I coin a new word, *autogram*. The *Washington* invents it and presents it to the public. No charge."

* * * * * *

"With the advent of the autogram one of two things must happen: either autogramists must learn to write distinctly enough to be read by lightning as well as in an unperturbed atmosphere, or the inventors of the autogram must arrange a system of typewriting for murderers of chirography. Behold two horns to the dilemma, neither of which these murderers are likely to take; consequently I predict quite a monkey-and-parrot time for the receivers of countless autograms, and rather fancy that Western Union stock will not become depressed at the last news from the electric pole."

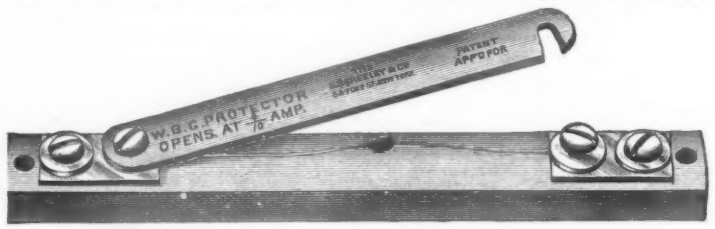


FIG. 1.—ONE WIRE "W. B. G." FUSE PROTECTOR.

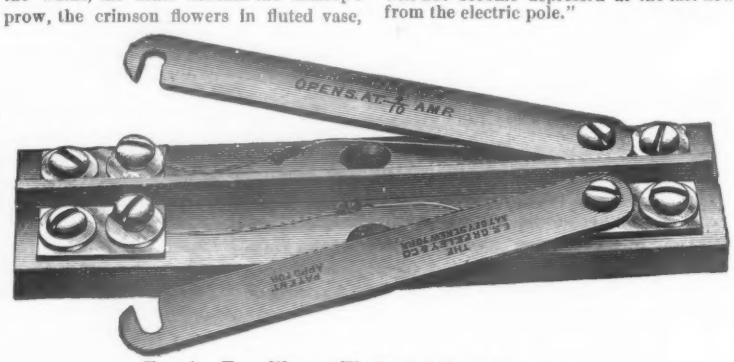


FIG. 2.—TWO WIRE "W. B. G." FUSE PROTECTOR.

A Union of Electrical Interests.

One of the New York dailies last week contained quite a lengthy account of a proposed so-called "electric trust," which included a number of electrical supply houses. Among the houses mentioned as considering the matter, were the Empire City Electric Company, and Alexander, Barney & Chapin, of New York; the Union Electric Manufacturing Company, of Bridgeport; Pettingell, Andrews & Company, of Boston, and the Southern Electrical Supply Company, of Baltimore. These are all well known houses, but as far as could be learned no decided steps have as yet been taken, although the matter has been generally discussed, and it is possible some arrangement may be entered into by a few of the companies named, to secure full advantages in the matter of purchases and the prevention of the cutting of prices.

The removal of the Macon, Ga., telephone exchange to its new building on Second street, near Poplar, will take place in about four weeks. The delay in removal has been caused by the non-arrival of cables.

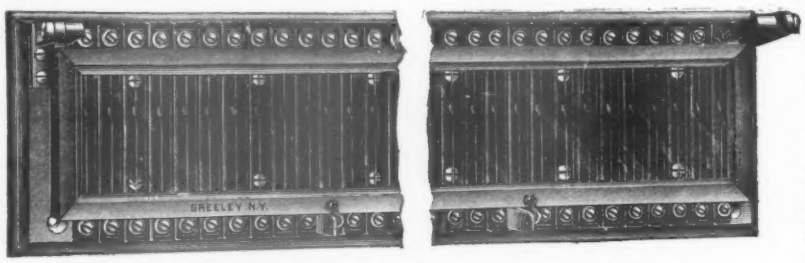


FIG. 3.—FIFTY WIRE "W B. G." FUSE PROTECTOR BOARD.

The "W. B. G." Protector.

On this page we publish cuts of the "W. B. G." protector. The inventors of this device are practical telegraph and telephone men and understand fully the necessity nowadays of a thoroughly reliable protector for telephone and telegraph stations and instruments. Of course any device that would be efficient in these two lines of electrical business would be equally so in others, such as burglar alarms, messenger and clock service, and in all cases where apparatus is exposed to damage from heavy or abnormal currents. The protectors are mounted one, two and three on a base (which is of vulcanized fibre) and in sections of 50, handsomely finished, as shown in the cuts.

The single, double and triple protectors are intended for use at telephone subscribers' stations, and are mounted to accommodate "single," "metallic" and "Law system" wiring. The sections of 50 are intended for use at central offices or any place where a large number of wires enter. They are also mounted to order.

The main feature of the invention is the manner in which the fuse is melted by the generation of heat in the small coil of comparatively high resistance wire, which is wound upon one end of the fuse and which is part of the circuit. The coil is formed of German silver wire of size and length necessary to produce heat enough to melt the fuse upon the passage of any current that it may be deemed desirable to have the line "open" at. For ordinary use at subscribers' stations they are wound to open the line at about 4-10 ampere, and for use at other places, such as central offices, where more delicate apparatus may need protection; they are wound accordingly.

The principle upon which it operates is well known and very simple, and it is evident, therefore, that the device is protection against the "sneak" current so destructive to electrical apparatus containing electro-magnets and coils of fine wire, as well as against heavy or abnormal currents.

It is also used in cable boxes, and by a very simple arrangement forms good protection against lightning as well as strong currents.

These devices are already manufactured and on sale by the supply house of the E. S. Greeley and Co., of New York, who are headquarters for the goods.

Model Motive Power.

The Baltimore and Ohio Railroad Company has recently placed in service on its fast trains between New York, Philadelphia, Baltimore and Washington, three new engines which are doubtless the finest and fastest ever built in this country. These new flyers have driving wheels six feet six inches high and cylinders 20 inches by 24. The large cylinders give them tremendous power, and the high drivers protect the machinery from the rack and strain incident to driving smaller engines at great speed. There is practically no limit to the speed to which these new marvels may be driven and they skim over the rails as smoothly as a swallow over a lake.

Another recent addition to the motive power of the company is a consignment of eight powerful 10 wheel passenger engines, designed for service on the mountain divisions. These are the heaviest 10 wheel engines ever constructed, weighing 67½ tons. They have driving wheels six feet two inches high and cylinders 21 inches by 26. One of these machines performs the work heretofore requiring two of the ordinary class, and they take the heavy through express trains up the mountain grades quickly and with perfect ease.

The Mt. Clare shops of the company have recently completed an order for 10 switch engines of the highest type, and sufficiently powerful to make up a train equal to the full drawing power of a consolidation freight engine. Also three new heavy eight wheel passenger engines, having driving wheels five feet eight inches, and cylinders 20 inches by 24. These engines are now doing excellent work; they are very powerful and susceptible of great speed.

In addition to the foregoing the company has now under construction at its Mt. Clare shops 10 powerful 10 wheel engines designed for fast freight service and for heavy passenger trains on occasion; also 12 consolidation freight engines of great power.

These additions to its motive power are in line with the other great improvements constantly being made in the general betterment of the B. & O. property by its present management, which have been noted by the press from time to time, and the rapid augmentation of the passenger traffic of the company indicates that the public is quick to recognize the present and constantly increasing efficiency of its train service.

The Fitchburg Steam Engine Company's High-Speed Engine.

The commercial development of the electric lighting business has had a marked influence upon steam engine construction within the past few years. A dozen years ago dynamos for electric lighting were practically unknown in this country, and the demand which was made upon their first appearance for the closest regulation of speed in order to get anything like satisfactory results showed that what had been called satisfactory regulation for general purposes was very far from perfect, and from what dynamos must have. The improvement in dynamos has been such, and the public acceptance of the electric light is so well assured, that the regulation of engines demanded then would not perhaps be demanded now if it had not so raised the standard that now perfect regulation is demanded, and rightly, for all classes of work.

The first impulse, in order to meet the demand of the dynamo, was toward high-speed engines, making from 240 to 350 revolutions, where a sensitive shaft-governor could be used, and any change of load be sooner felt and more quickly acted upon. This resulted in the designing by many builders of such engines, some good and some bad, but in general accomplishing the end sought, a sure and practically perfect regulation of speed under abrupt and extreme variations of load. The question of economy in use of steam came later and is a second and as important a test of the availability of the engine, while reliability and durability are essentials.

The effect has been also to bring the low-speed engines up to a far closer regulation than formerly, and in some cases to as good results as are to be obtained from high-speed. while for economy of fuel and reliability they are superior except under particular circumstances.

The Fitchburg Steam Engine Company, of Fitchburg, Mass., build low-speed engines, with independent double-ported valves, to run high pressure, condensing or compound condensers. The latter in pairs "tandem," all these being used in electric light stations with just as good results for regulation as can be obtained from any high-speed engines. They also make a strictly first-class high-speed engine, a cut of which we give herewith, which has the same workmanship in it as is in their largest low-speed horizontals, than which there is none better in the country. The same patented counter balanced shaft or wheel governor is used as in the low-speed engines, it being very simple and so arranged that in sizes above 60 horse-power it can be changed to run the engine from left to right, or *vice versa*, in 20 minutes. The valve used is their patented expansible valve, which is claimed to be the only one in existence which positively follows up all wear of the valve or seat, preserving a perfectly straight bore of seat and face of valve. These valves are guaranteed capable of being kept perfectly tight for 25 years with cost only of an hour's time of engineer once a year or year and a half. It is the valve used in all the engines of the company for 14 years.

The frame is the ordinary hooded form, giving strength and convenience in getting at all parts. The shaft is of best gun iron with a patented device preventing possibility of breakage at the wrist pin to injure the rest of the engine. The working parts are well proportioned, and the whole engine is designed for economical, reliable, satisfactory and solid work.

The company will be glad to receive communications from any one direct, or through their agencies. Among others, they have in Chicago an office at 85 Dearborn street, Granville Kimball, manager; in Philadelphia, at Builders Exchange, Geo. H. Connor, manager; in New York, 136 Liberty street, William Barnhurst, manager. They are just erecting very large new shops in Fitchburg.

The Fort Wayne Electric Company is considerably behind on its orders for fan motors, the demand being enormous.

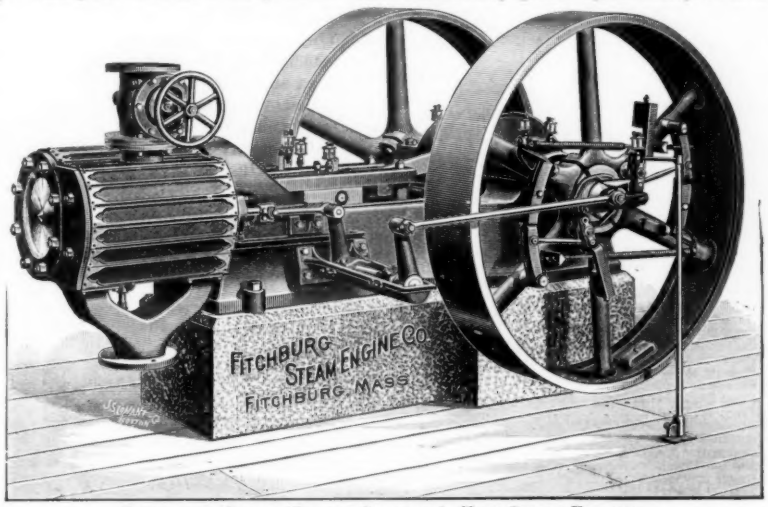
A Successful Storage Battery Road.

On the first of April, 1891, the Milford and Hopedale, Mass., electric street railway was opened. The motive power used is a storage battery system under the patents of W. L. Stevens. The plant consists of 140 cells divided into 12 divisions, called "trays," and six of these trays are placed on each side of a car. Ten of these trays consist of 12 cells, and the remaining two of 10 each. The dimensions of a tray of 12 cells are 26 inches long by 17 wide and about 15 high.

About 3½ hours is required to charge the batteries, which are placed on charging tables in the car house, corresponding with the height of the battery space in the car. The motors on the car are of 7½ horse-power each. The weight of a car equipped for service is about six tons.

The track is of standard gauge and a 35 compound chair rail is used The rolling stock of the line consists of six elegant solid mahogany cars, which cost $6,000 each. Each car is equipped with a compound controlling switch and electric brake, besides a friction brake.

The steepest grade on the line is 1,400 feet long, and has a rise of 7 feet in every 100. This grade includes a sharp curve. The



FITCHBURG STEAM ENGINE COMPANY'S HIGH-SPEED ENGINE.

cars now run for 30 miles without a change of batteries, but it is claimed that they can make 40 miles. The company reports that it has not spent one cent in repairs since the opening of the road.

The Milford and Hopedale electric street railway is owned by the Grafton and Upton Railroad Company, and the officers of the latter are also those of the former. Mr. E. P. Usher is president; Mr. Albert Morse of Boston, treasurer; Mr. Charles B. Powers, superintendent, and Mr. F. W. Morse, general agent. With the exception of Mr. Albert Morse, all are residents of Grafton.

Edison Dividend.

The Edison General Electric Company has declared its seventh quarterly dividend of two per cent., payable August 1, to stockholders of record, July 11. The transfer books close July 11 and re-open August 3. This dividend is at the rate of eight per cent. per annum. The ability to pay such a good rate is an evidence of the careful and progressive financial management now evident in the handling of this company's large business.

Westinghouse Matters.

The following circular has been promulgated:

Inasmuch as holders of considerably more than two-thirds of the stock of the Westinghouse Electric and Manufacturing Company assented to the plan of reorganization, the reorganization committee have decided to limit to July 8, 1891, inclusive, time in which stockholders may deposit their stock with Mercantile Trust Company, of New York. Notice is hereby given that after that date stock will only be accepted subject to such additional conditions as the committee may impose.

AUGUST BELMONT,
CHARLES FAIRCHILD,
BRAYTON IVES,
Reorganization Committee.

New York, June 24, 1891.

Life of Submarine Cables.

Our attention has been called to the following paragraph, which appeared in the *Mechanical World*, of May 2: "A submarine telegraph cable has a life of 10 or 12 years. If a cable breaks in deep water after it is 10 or 12 years old, it cannot be lifted for repairs, as it will break of its own weight," etc.

To those acquainted with the subject of telegraphy, the incorrectness of the statements that a cable has a life of only from 10 to 12 years, and that after that age it cannot be repaired in deep water, is at once apparent. The general public, however, would be naturally ready to accept, without hesitation, the expression of an opinion coming from a presumable authoritative source, and we think our contemporary should be more careful and take some little pains to ascertain the facts of the case before making such random statements.

A hard and fast law as to the life of a cable cannot be laid down, for the duration of the sheathing wires is governed by more than one element. The quality of the galvanizing, the presence or absence of such protection as compound, tapes or hemp, and the physical and chemical nature of the bottom, are considerations which must be taken into account. To show that the *Mechanical World* is very far astray in its calculations, and that submarine cables may have a life of more than 10 years, and that they can be successfully repaired at even a considerably greater age, we may observe that there are now in existence, and in working order, about 44,000 knots of cables, having a life of 15 years and over, of this amount some 21,000 knots are 20 years and over of age. There are several instances of cables now working over 25 years old, but these are principally lines of unimportant length, and lying in shallow water. The cables we have cited are laid in all portions of the globe, and submerged in all sorts of depths, and although the companies owning them have spent and are prepared to expend considerable sums in repairs, we do not think that the complete renewal of each section every 10 years has entered into their calculation.

Present experience would lead us to allot to submarine cables laid under favorable conditions an average life of from 30 to 40 years, but, as before stated, no hard and fast figure can be given any more than it is possible to determine the number of years that each newly-born child will live; but there is abundant evidence to prove that our contemporary is distinctly wrong when he says "a submarine cable has a life of 10 or 12 years."—*Electrical Review*, London.

TO THE EDITOR OF ELECTRICAL REVIEW:

This is interesting not only as showing the real life of cables but also the proneness of poor humanity (even that portion which should be scientific) to error. This is of especial interest now that several of our electric companies want to go under *water*.

We have recently made for the Narragansett Electric Company, Providence, six cables, No. 0, and two No. 6, to carry current under the Providence river. We are now making a cable 7,000 feet long, equal to No. 0, to carry alternating current across the bay at Tacoma, Wash. This cable will weigh about 10 tons making a good car-load.

Although the Providence people have had one of our rubber cables nearly two years, and it now has an insulation resistance under the river of over 2,000 megohms, we are now using gutta-percha for all sub-aqueous work.

Yours truly,
HENRY A. REED.
Sec. and Mgr. Bishop Gutta-Purcha Co.
New York, June 30.

Oakland, Cal.—Star Light Company; capital, $2,500,000.

Santa Ana, Cal.—Santa Ana Gas & Electric Company; capital, $100,000.

Atlanta, Ga.—The Grant Park Electric Railway Company; capital, $100,000.

Canajoharie, N. Y.—The Canajoharie Electric Light Company; capital, $10,000.

Stoughton, Wis.—Stoughton Electric Light & Power Company; capital, $10,000.

Anderson, Ind.—The Anderson Electric Street Railway Company; capital, $200,000.

Sutton, W. Va.—The Sutton & Williams River Telephone Company; capital, $10,000.

Granitesville, S. C.—Cotton Shoals Electric Light & Power Company; capital, $10,000.

Milwaukee, Wis.—Milwaukee & Wauwatosa Electric Company; capital stock, $75,000.

New Orleans, La.—Enterprise Construction & Supply Company, Limited; capital, $50,000.

Camden, N. J.—The Universal Electric Railway Construction Company; capital, $500,000.

Cedar Rapids, Va.—Cedar Rapids & Marion City Railway Company; capital, $400,000.

Waterville, Me.—Waterville & Fairfield Light & Railway Company; capital, $200,000.

New York, N. Y.—Union Electric Company; incorporated in West Virginia; capital, $250,000.

Belfast, Me.—Islesboro, Northport & Belfast Telegraph & Telephone Company; capital, $10,000.

New York, N. Y.—Portable Electric Lamp & Power Company; incorporated in West Virginia; capital, $1,000,000.

Chicago, Ill.—Chattanooga Water & Electric Company; incorporated in West Virginia to do business in Chattanooga, Tenn.; capital, $50,000.

Harvard, Ill.—The Harvard Electric Light & Power Company; capital, $15,000; incorporators, James E. Keelyn, A. W. Young and E. L. Church.

Portland, Ore.—Portland, Nehalem & Astoria Railway Company, with Thomas H. Tongue, J. D. Merryman, F. A. Bailey and J. W. Shute, of Washington county, Thomas Braden, of Columbia county, and J. McCraken, T. F. Osborn, C. H. Dodd, G. W. Staver and J. H. Smith, of Multnomah county, as incorporators. The capital stock of the company is fixed at $100,000, and the object of the company is to build, own and operate roads and telegraph lines between Portland and Astoria, and between Hillsboro or Forest Grove and the Nehalem river.

Fixture Dealers Organize.

A press despatch from Cincinnati, June 28, is as follows:

The dealers in gas and electric light fixtures from leading cities in the country, who have been in session in this city during the past three days, completed their permanent organization yesterday. This new association just formed is called the National Association of Gas and Electric Light Fixture Dealers, and its object is to foster the commercial and social interest of those engaged in that trade.

The following officers were elected: President, L. D. Cross, of Kansas City; vice-president, E. F. Brooks, of Washington; secretary, P. V. Dwyer, of St. Paul; treasurer, John Kelly, of Pittsburgh. The association adjourned yesterday afternoon, the time and place of next meeting to be fixed by the executive committee.

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No attention will be paid to communications for the REVIEW without the *name and address of the writer.*

NEW YORK, JULY 11, 1891.

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It is stated that Mr. Ader, the inventor of the telephone bearing his name, has invented an electrically operated flying machine, and has made a successful flight at a height of 66 feet for a distance of 300 to 400 yards. Details of the apparatus will be looked for with interest.

There has been quite an epidemic of fires lately in New York city, and curiously enough not one of them has been put down to electricity. Perhaps in no case was there an electric wire handy which could be made to play the scapegoat, although as electric wires are almost everywhere nowadays that is scarcely probable, and it should certainly be put on record that out of a considerable number of important fires electricity has not been held responsible for a single one. It may be that electrical men are getting to be more careful, and it also may be that the people whose business it is to investigate fires and their causes are getting to be less rash at jumping at conclusions on insufficient evidence. We are inclined to believe in the latter theory because they, the investigators, have made such flagrant mistakes in this line, and their statements have so often been disproved, that it is not surprising that they should have learned to be more cautious.

Ever and anon a government bureau will advertise that examinations will be held for the position of electrician to the Bureau of Something or other; salary $1,500, or "thereabouts." A man who has held several such positions said to the writer: "Any live man who is worth $1,500 in a government position, after passing the required examination, is worth $2,500 to himself or some one else." It doesn't sound patriotic, but observation and experience would seem to prove it true. Unless a real live man is seeking a certain line of experience, or is entirely independent of whatever salary he may make as a government official, he would better let such positions alone. No better exposition of the effects of long tenure of public office can be read than that set down by Nathaniel Hawthorne in his sketch of the Custom House in "The Scarlet Letter," which see.

OUR PROPHET.

The prognostications of "The Prophet," which have appeared from time to time in the REVIEW, are creating something of a furore with the public. Many paragraphs have been copied by the daily papers; sometimes with credit, sometimes without. When people begin to take your property it is confirmatory evidence that you have, or had, something of value. But the REVIEW wants its contemporaries to stop filching. We don't need any confirmatory evidence as to the value of "The Prophet's" soothsayings.

A large number of inquiries as to "The Prophet's" identity have reached us. We have decided to tell who he is. "The Prophet" is a man of great originality, who can wield a facile pen, and discuss anything from nitrogen to tanning in the space of one column and get an electrical meaning out of every paragraph. That's who he is.

In addition he is of such a modest and retiring disposition that it is only under the protection of a *nom de plume* he can be persuaded to address the public. Therefore, good people, be content to know him only as "The Prophet;" read, mark, learn and inwardly digest his writings and "The Profit" will be yours.

TESLA'S RESEARCHES IN RAPID ALTERNATION AT HIGH TENSION.

The full text of Nikola Tesla's lecture on high frequency and high tension currents for electric lighting is given in this issue of the REVIEW. The paper is of unusual length but is of transcendant interest and we have made special efforts to present the entire paper in one number. The subject matter discussed is pioneer work, the results are very striking; in general they have been already published in the REVIEW. They will set hundreds of explorers at work in a new and promising field of investigation; whether or not a commercial system of lighting will grow out of it remains to be seen. The lecturer indicates that a condenser can be utilized to increase at will the frequency of alternation; that a mere change of its static capacity will be followed by a corresponding change of frequency. The system of distribution recently patented by Mr. Tesla, and described in the last REVIEW, is based upon this principle. A comparatively low tension current of ordinary periodicity—such a current as furnished by commercial alternators now in use—can be generated at the power station, and conveyed to the point of consumption and there raised both in tension and frequency by a local device comprising a condenser and an induction coil. Whether currents of such enormous tension could, after conversion, be conveyed with safety through a building, or be kept upon the conductor; whether the leakage which must inevitably occur would not lower the efficiency of the system until it would be crowded out of sight in competition with the systems of lighting now in use; whether the self-induction of a few hundred feet of wire would not militate seriously against a successful result, and necessitate a converting, tension-raising, period-transforming device for every lamp used, are questions not discussed in the lecture, but readily capable of experimental demonstration. Mr. Tesla covered a vast experimental territory in his investigation, as the great variety of results clearly shows. The work will now be followed by numerous minds in such a variety of ways that its commercial possibilities cannot long remain in doubt.

HIGH TENSION vs. LOW TENSION.

With the rapid advances that are being made in central station electric lighting practice, the battle between high tension and low tension systems of distribution wages with unabated vigor. The interest generally felt in the contest is all the greater from the fact, that in spite of the alternate current transformer system having started in the race a long way behind its low tension direct current rival, it has of late years been so surrounded with improvements of every sort, and so much attention has been paid to its development and perfection, that it is now on fairly equal terms in respect to being a question of every-day practice, remote from all suspicion of experiment or uncertainty.

The impetus which central station work has acquired in England, during the last year or two, since legislative obstacles have wisely been removed, has very naturally brought into prominence adherents of either system, and quite lately there has been considerable discussion between the two schools in the hall of the Institution of Electrical Engineers, and in the columns of the English technical press. Mr. R. E. Crompton, read a paper a short time ago on "The Most Economical Mode of Feeding a Low Pressure Network," in which he argued that distribution by low tension currents is more economical than by alternate currents of high potential. Mr. Crompton's figures relating to the cost of high tension mains and their "upkeeps" were vigorously attacked by the alternate current men, and his conclusions were by no means generally accepted.

Of greater interest than that, however, is it to find two such authorities as Sir Wm. Thomson and Mr. Preece declaring themselves one in favor of low tension direct distribution and the other in favor of alternate current high tension distribution. In a very interesting paper, which contains much information very clearly put, on "Some Points Connected with Mains for Electric Lighting," Mr. Preece says the following:

"The use of high or of low pressure should not be a question of opinion or of objection. The supposed waste, danger and difficulties of the one are disappearing under the able tuition of experiences, while the complicated regulation and variable distribution of the other are submitting to inventive skill. It is now a question of calculating and finance. The only variable is the number of feeding points. The determining cause and the uncertain element is the density of lamps per acre or mile of street. We start with this initial difficulty—that we do not know our customers and we have to prepare for a visionary *clientèle*.

"This paper has been a little discussive. Its principal object is to direct attention to the simplicity of the two-wire parallel system of distribution, to the security of the concentric main, to the devices to promote the safety of the high pressure system, and, above all, to the necessity for regarding the whole question from the engineering maintenance point of view, rather than from that of the speculative promoter."

That puts the case in a nut-shell, and at the same time shows a distinct leaning toward the alternate current system of distribution.

Sir Wm. Thomson, in speaking in a general discussion on both the above-mentioned papers, said that on the whole he thought it was injudicious to rush to alternate currents for distribution purposes, and he himself rather inclined to continuous current distribution by feeders, as described by Edison. He was quite aware of the processes which had led to the alternate current system being usually preferred, and of the great advantages which in some cases could be realized by its use; but he believed that in future the direct system would predominate. The general idea in putting the generating system at a distance was to obtain cheaper coal, but he doubted whether more than 6*d.* (twelve cents) per ton could be saved in this way. The possible use of condensation was another item, but so far as he was aware triple expansion condensing engines had not come into use for electric lighting. Rent of land, however, was an important consideration, as well as the necessity of diminishing vibration. Both these told in favor of the distant station, and, in his opinion, no other consideration ought to prevent engineers from putting their stations as near as possible to the consumers.

To put it colloquially, Sir William comes down "flat-footed" in favor of the low tension system under almost any circumstances. Mr. Preece is consulting engineer to the corporation of Bristol, and has designed a central station system for distribution by alternate currents for that town. Sir William Thomson has specified low tension continuous current distribution for Glasgow, so it is evident that each has the courage of his convictions.

CORRESPONDENCE.

OUR BOSTON LETTER.

Edison System of incandescent lighting is being installed in the custom house, at Newport, R. I.

The Southern New England Telephone Company has begun work at Bridgeport, Conn., putting its wires underground.

Mr. W. G. McAdoo, Jr., president of the Knoxville, Tenn., Electric Railway Company, has been enjoying a few days sojourn in this city.

Mr. Willis L. Adams has accepted the eastern agency of the Electric Merchandise Company, of Chicago, and probably will locate in this city.

General Manager H. A. Royce, of the Thomson Electric Welding Company, has returned to this city after an absence in Europe of two months.

Mr. John Leslie, superintendent of the electric light and gas company at Yarmouth, Nova Scotia, was in this city for a few days during the present week.

Melrose, Mass., selectmen, by nearly an unanimous vote at a recent meeting, decided to establish an electric light station to be owned and operated by the town.

The Thomson-Houston Motor Company has issued an illustrated pamphlet giving description and particulars of the company's electric tramways for mills and factories.

The New England Telephone and Telegraph Company has asked the Worcester, Mass., authorities for permission to put wires of the former underground in the city named.

More Electric Railways.—The street railway companies of Haverhill and South Hadley Falls, Mass., have decided to adopt electric propulsion on their respective roads.

Pittsfield, Mass., Electric Light Company has distributed among its customers and prospective patrons a neat pamphlet entitled, "Plain Talks About Incandescent Electric Lighting."

The Eastern Electrical Supply and Construction Company, of this city, sole agents for the Johnson Dry Battery, is selling a large number of these meritorious batteries to the electrical trade.

Mr. J. H. Burghardt, with the Page Belting Company, now makes his headquarters at his company's Eastern office, No. 17 Federal street, this city. Mr. Burghardt reports business as active in his line.

Tropical American Telephone Company, Limited, will hold its annual meeting at Long Branch, N. J., July 29, 1891. Matters of great importance, including early payment of another dividend and purchase of new patents, will receive attention.

The Edison Electric Illuminating Company, this city, has issued a pamphlet entitled, "Wiring Requirements," which gives an interesting and instructive treatise on the subject named, together with useful information regarding the company's service.

The Quincy, Mass., Electric Freight Railway Company has made application to the authorities of that city for permit to lay tracks through the principal business streets for the purpose of conveying freight from the several stone yards and quarries to the depots and wharves.

Mr. J. Edward Wallace, manager of the electric railway department of the Eastern Electrical Supply and Construction Company, this city, has been in the West about a month pushing his company's specialties among the street railway people. Mr. Wallace is meeting with success wherever he goes.

Prosperous Electric Road.—Authentic advices of recent date from Dover, N. H., state that "the electric railroad connecting the city named with Great Falls, N. H., earned from August 17, 1890, to June 20, the present year, $30,148.60." This, it is said, "is at the rate of seven per cent. on the money invested.

Mr. Frank A. Magee has resigned the position he held so long and creditably with the E. S. Greeley Company, and has accepted the management of the Eastern department of the Engineering Equipment Company, of Philadelphia, and the Underwood Manufacturing Company, of Tolland, Conn. Mr. Magee has established his headquarters at No. 126 Pearl street, this city.

The Evans Friction Cone Company, of this city, has filled the following orders for its dynamo frictions quite recently: Cedar Rapids, Ia., Electric Light and Power Company; National Transit Company, Millway, Pa.; Edison General Electric Company, for an isolated electric light plant in a United States government light-house tender; Warren Electric Light Company (second order); Gramme Electric Light Company, Paris, France, for use in the company's factory; Edison isolated electric light plant at Watervleit Arsenal (United States), West Troy, N. Y., and for the isolated plants of Mr. E. G. Barnard, Troy, N. Y.; Messrs. Hughes & Gathrop, Pittsburgh, Pa., and Messrs. W. S. Griffiths & Company, Philadelphia, Pa. The Evans Company has recently been successfully introducing many of its speed cones at factories of electric light manufacturing companies and manufacturers of wire; W. I. B.

Boston, July 4.

OUR ALBANY LETTER.

President A. N. Brady, of the local electric illuminating company, left Thursday with his family for their summer home at Asbury Park, N. J.

The Saratoga, N. Y., taxpayers voted Wednesday affirmatively on the question of lighting part of the electric street lamps on the each and every night system, and the remaining 136 on a moonlight schedule for the ensuing five years.

The People's Railway Company, of Syracuse, N. Y., has been given a franchise to operate by electricity. The company is allowed until July 1, 1893, to complete the electric system.

The schooner "F. H. Odiorne," discharging a cargo of granite block at the Greenbush dock, became fastened to the Western Union telegraph cable Thursday. Neither boatmen nor telegraph men were able to free her, and a diver will be employed for the work.

The Western Union Telegraph Company at Newburgh, N. Y., has received eight self-winding, self-adjusting electric clocks, which are being put up in various portions of the city, principally in manufactories. These clocks are the same that jewelers have, and are set daily by telegraph from Washington, being connected direct by a special wire. At the present time 11 of them are in operation in Newburgh. This clock, like the telephone, is not sold, but is rented by the year at $15. L. M. W.

Albany, June 27.

OUR CHICAGO LETTER.

Mr. M. E. Baird, general agent of the Eddy Electric Motor Company, spent a day in the city last week. Mr. Baird is returning from an extended trip through the West and Northwest and reports an excellent trade.

Mr. E. W. Little, general manager of the Interior Conduit & Insulation Company, of New York, visited the Chicago office of the Company this week. Mr. Little is making a short visit to some of the larger cities of the West. He is accompanied by Mrs. Little.

The "Jewel" incandescent lamp, which Wm. Hood of 239 La Salle street is introducing, is creating considerable interest among lamp consumers. Flattering letters verifying the claim for long life, high efficiency and economy in consumption of current are received daily. Mr. Hood is also agent of the Mosher arc lamp for incandescent circuits, and as such is receiving numerous orders and enquiries for an arc lamp that is desirable for a low tension current.

A Recent Report to the city of the amount and cost of lighting the city of St. Louis, most of which is illuminated by electric lights, may be of interest to the public. There are 243 miles of street lighted by arc lights, employing 2,129 arc lights; 20 miles of street lighted by gas and four miles by gasoline. For the gas lighted streets 771 lamps are used, and 169 gasoline lamps for the gasoline district. One thousand five hundred and fifty-five incandescent lamps are used for alley lighting. The number of miles of street lighted by electricity exceeds that formerly lighted by gas by 113 miles. The amount appropriated by the city to pay for the city's lighting was $301,454.04; the expenses only amounted to $225,306.75, leaving a balance to be returned to the treasury of $46,147.29. L. W. C.

Chicago, July 4.

The Empire City Electric Company.

The Empire City Electric Company, 15 and 17 Dey street, New York, has decided to close up its business. This action was decided upon at a meeting of the company recently. The Empire City is a well-known company handling electrical supplies, and it is with much regret that we chronicle its decision to retire from the electrical business. The affairs of the company will be promptly and satisfactorily adjusted and the business entirely closed out during the next few weeks.

The Faraday Carbon Company.

The Faraday Carbon Company, Pittsburgh, Pa., one of the earliest and most successful carbon manufacturers, is now occupying its new factory at Jeannette, a suburb of Pittsburgh. This move increases the facilities of the company four-fold, and the newest and best apparatus to be obtained has been put in. The company has its own gas well immediately adjoining the factory.

The Faraday Company denies any connection with a carbon trust—is running its business entirely independent of any combination or trust. Mr. D. D. Dickey is now, as for eight years past, the sole manager,

PROGRESSIVE ELECTRICAL INVENTIONS.

IMPROVED LIGHTNING ARRESTER.

In the accompanying engraving is illustrated an improved lightning arrester recently patented by Elihu Thomson. It is applicable to all systems of distribution of electric currents, whether direct or alternating, and is designed to prevent injury to the generator or translating devices. The device consists of a self-inductive device which is interposed between the ordinary lightning arrester, as illustrated at P and the line. This self-inductive device is preferably a

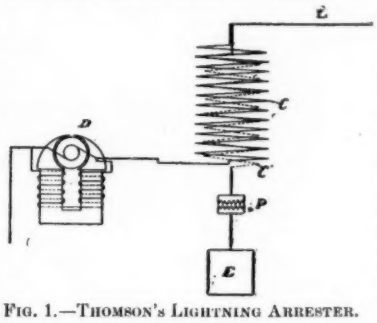


FIG. 1.—THOMSON'S LIGHTNING ARRESTER.

coil C^1, and is enclosed within another coil C connected to the dynamo or other apparatus to be protected. The two coils are well insulated from each other. Their effect is to cause a lightning or other static discharge, when passing directly to ground through the path C^1, of comparatively low self-induction to generator an opposing counter electromotive force in the coil C which will oppose the passage of the lightning discharge through the generator.

In order to guard against the formation or maintenance of area across the discharge plates of a lightning arrester, Professor Thomson has devised the apparatus illustrated in the second diagram, which consists of a counter electromotive force generator in the form of a number of polarizing cells arranged in series. These cells may be composed of a series of lead plates separated by a moist substance, which may be either a liquid or a strip of felt soaked in

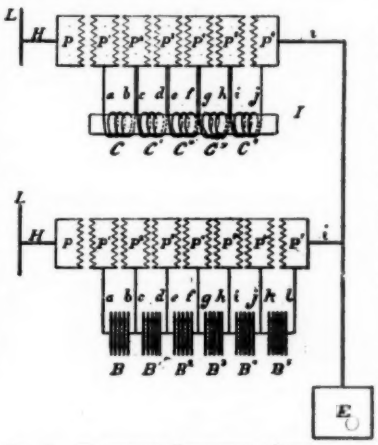
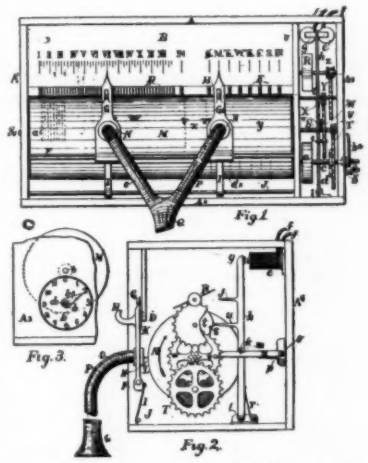


FIG. 2.—THOMSON'S LIGHTNING ARRESTER.

some conducting solution, such as a salt or acid. When an arc is formed the counter electromotive force of the cells is sufficient to quickly extinguish it. In the case of an alternating current circuit, counter inductive devices consisting of a series of coils wound upon an iron core should be substituted for the polarizing cells. The polarizing cells are illustrated in the lower part of the diagram, a sufficient number being used around each pair of lightning discharge plates to guard against the flow of current from the line to earth. The substitution of counter inductive devices for an alternating current circuit is shown in the upper part of the diagram. In this case the number of coils provided at C should be sufficient to set up an electromotive force greater than the electromotive force of the line, so as to prevent the leakage of the alternating current to earth.

COMBINED PHONOGRAPH AND TELEPHONE.

In the accompanying engraving is illustrated a signal attachment for telephones, by which a subscriber can set his instrument so as to phonographically reply to an operator who calls him during his absence. The apparatus comprises a phonograph cylinder, driven by a train of clock-work, controlled by a detent adapted to be released by the current which flows over the line when the subscriber is called up. In front of the cylinder are reproducing styles, connected to a phonograph tube, which may be put over the transmitter of the telephone. The operator, on leaving his office, sets his instrument by means of a pointer at the hour of the day and the day of the week when he will return, and if during his absence he should be called up, the clock-work will be released and the phonograph cylinder permitted to make a single revolution, transmitting the message from the particular line of characters with which the reproducing style is in contact, and developing a sound message which is transmitted electrically to the distant operator through the telephone. Across the containing box, parallel with the phonograph cylinder, is a rack D which is provided with a number of notches corresponding to the number of messages which will fill the wants of the subscriber, and the messages are recorded on the phono-



PHONOGRAPH AND TELEPHONE COMBINED.

graph blank by setting the styles in a position corresponding to one of these notches, by sliding it longitudinally, and then allowing a detent K to fall in one of the notches. The record indicating the day of the week is put on the opposite side of the cylinder from the hour record, and in transmitting the intelligence the instrument will first give the hour of the day when the subscriber will return, and then the day of the week. The apparatus is the invention of Messrs. Sundeen, Molender, Anderson and Carlsen, of St. Paul, Minn.

IMPROVED CARBON FILAMENT.

George Erlwein, of Berlin, has patented an incandescent lamp provided with a filament coated with nitrides of boron by soaking the filament in liquid boron compounds free from oxygen, and then gradually heating it to a red heat in the presence of volatile nitrogenic compounds, as ammonia, the heating being accomplished by passage of a current. A filament so treated is claimed to be free from atomization or dispersion.

American Institute of Electrical Engineers.

At the Regular Monthly Meeting of Council of the American Institute of Electrical Engineers the following delegates were appointed to attend the Frankfort Electrical Conference, in accordance with a resolution adopted at the general meeting, May 21: Carl Hering, chairman; Prof. R. O. Heinrich, Nikola Tesla, Dr. E. L. Nichols. Professor Heinrich is already in Europe and Mr. Hering sailed July 2, on the "Normannia." Mr. Tesla is not certain that he will be able to go. Fifteen associate members were elected, and Mr. Jesse M. Smith was transferred from associate to full membership. No further meetings of the Institute will be held until September.

Experiments with Alternate Currents of Very High Frequency and their Application to Methods of Artificial Illumination.

A LECTURE DELIVERED BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, AT COLUMBIA COLLEGE, MAY 20, 1891, BY NIKOLA TESLA.

There is no subject more captivating, more worthy of study, than nature. To understand this great mechanism, to discover the forces which are active, and the laws which govern them, is the highest aim of the intellect of man.

Nature has stored up in the universe infinite energy. The eternal recipient and transmitter of this infinite energy is the ether. The recognition of the existence of ether, and of the functions it performs, is one of the most important results of modern scientific research. The mere abandoning of the idea of action at a distance, the assumption of a medium pervading all space and connecting all gross matter, has freed the minds of thinkers of an ever-present doubt, and, by opening a new horizon—new and unforeseen possibilities—has given fresh interest to phenomena with which we are familiar of old. It has been a great step towards the understanding of the forces of nature and their multifold manifestations to our senses. It has been for the enlightened student of physics what the understanding of the mechanism of the firearm or of the steam engine was for the barbarian. Phenomena upon which we used to look as wonders baffling explanation, we now see in a different light. The spark of an induction coil, the glow of an incandescent lamp, the manifestations of the mechanical forces of currents and magnets are no longer beyond our grasp; instead of the incomprehensible, as before, their observation suggests now in our minds a simple mechanism, and although as to its precise nature all is still conjecture, yet we know that the truth cannot be much longer hidden, and instinctively we feel that the understanding is dawning upon us. We still admire these beautiful phenomena, these strange forces, but we are helpless no longer; we can in a certain measure explain them, account for them, and we are hopeful of finally succeeding in unraveling the mystery which surrounds them.

In how far we can understand the world around us is the ultimate thought of every student of nature. The coarseness of our senses prevents us from recognizing the ulterior construction of matter, and astronomy, this grandest and most positive of natural sciences, can only teach us something that happens, as it were, in our immediate neighborhood; of the remoter portions of the boundless universe, with its numberless stars and suns, we know nothing. But far beyond the limit of perception of our senses the spirit still can guide us, and so we may hope that even these unknown worlds—infinitely small and great—may in a measure become known to us. Still, even if this knowledge should reach us, the searching mind will find a barrier, perhaps forever unsurpassable, to the *true* recognition of that which *seems* to be, the mere *appearance* of which is the only and slender basis of all our philosophy.

Of all the forms of nature's immeasurable, all-pervading energy, which, ever and ever changing and moving, like a soul animates the inert universe, those of electricity and magnetism are perhaps the most fascinating. The effects of gravitation, of heat and light we observe daily, and soon we get accustomed to them, and soon they lose for us the character of the marvelous and wonderful; but electricity and magnetism, with their singular relationship, with their seemingly dual character, unique among the forces in nature, with their phenomena of attractions, repulsions and rotations, strange manifestations of mysterious agents, stimulate and excite the mind to thought and research. What is electricity, and what is magnetism? These questions have been asked again and again. The most able intellects have ceaselessly wrestled with the problem; still the question has not as yet been fully answered. But, while we cannot even to day state what these singular forces are, yet we have made good headway towards the solution of the problem. We are now confident that electric and magnetic phenomena are attributable to ether; and we are, perhaps, justified in saying that the effects of static electricity are effects of ether under strain, and those of dynamic electricity and electro-magnetism effects of ether in motion. But this still leaves the question, as to what electricity and magnetism are, unanswered.

First, we naturally inquire, What is electricity, and is there such a thing as electricity? In interpreting electric phenomena, we may speak of electricity or of an electric condition, state or effect. If we speak of electric effects we must distinguish two such effects opposite in character, and neutralizing each other, as observation shows that two such opposite effects exist. This is unavoidable, for in a medium of the properties of ether, we cannot possibly exert a strain, or produce a displacement or motion of any kind, without causing in the surrounding medium an equivalent and opposite effect. But if we speak of electricity, meaning a *thing*, we must, I think, abandon the idea of two electricities, as the existence of two such things is highly improbable. For how can we imagine that there should be two things, equivalent in amount, alike in their properties, but of opposite character, both clinging to matter, both attracting and completely neutralizing each other? Such an assumption, though suggested by many phenomena, though most convenient for explaining them, has little to commend it. If there *is* such a thing as electricity, there can be only *one* such thing, and, excess and want of that one thing, possibly, but more probably its condition, determines the positive and negative character. The old theory of Franklin, though falling short in some respects, is, from a certain point of view, after all, the most plausible one. Still, in spite of this, the theory of the two electricities is generally accepted, as it apparently explains electric phenomena in a more satisfactory manner. But a theory which explains better the facts is not necessarily true. Ingenious minds will invent theories to suit observation, and almost every independent thinker has his own views on the subject.

It is not with the object of advancing an opinion, but with the desire of acquainting you better with some of the results which I will describe, to show you the reasoning I have followed, the departures I have made, that I venture to express, in a few words, the views and convictions which have led me to these results.

I adhere to the idea that there is a thing which we have been in the habit of calling electricity. The question is, What is that thing? or, What, of all things, the existence of which we know, have we the best reason to call electricity? We know that it acts like an incompressible fluid; that there must be a constant quantity of it in nature; that it can be neither produced nor destroyed; and, what is more important, the electromagnetic theory of light and all facts observed teach us that electric and ether phenomena are identical. The idea at once suggests itself, therefore, that electricity might be called ether. In fact, this view has in a certain sense been advanced by Dr. Lodge. His interesting work has been read by every one, and many have been convinced by his arguments. His great ability and the interesting nature of the subject, keep the reader spellbound; but when the impressions fade one realizes that he has to deal only with ingenious explanations. I must confess, that I cannot believe in two electricities, much less in a doubly constituted ether. The puzzling behavior of the ether as a solid to waves of light and heat, and as a fluid to the motion of bodies through it, is certainly explained in the most natural and satisfactory manner by assuming it to be in motion, as Sir William Thomson has suggested; but regardless of this, there is nothing which would enable us to conclude with certainty that, while a fluid is not incapable of transmitting transverse vibrations of a few hundred or thousand per second, it might not be capable of transmitting such vibrations when they range into hundreds of million millions per second. Nor can any one prove that there are transverse ether waves emitted from an alternate current machine, giving a small number of alternations per second; to such slow disturbances the ether, if at rest, may behave as a true fluid.

Returning to the subject, and bearing in mind that the existence of two electricities is, to say the least, highly improbable, we must remember, that we have no evidence of electricity, nor can we hope to get it, unless gross matter is present. Electricity, therefore, cannot be called ether in the broad sense of the term; but nothing would seem to stand in the way of calling electricity ether associated with matter, or bound ether; or, in other words, that the so-called static charge of the molecule is ether associated in some way with the molecule. Looking at it in that light, we would be justified in saying, that electricity is concerned in all molecular action.

Now, precisely what the ether surrounding the molecules is, wherein it differs from ether in general, can only be conjectured. It cannot differ in density, ether being incompressible; it must, therefore, be under some strain or in motion, and the latter is the most probable. To understand its functions, it would be necessary to have an exact idea of the physical construction of matter, of which, of course, we can only form a mental picture.

But of all the views of nature, the one which assumes one matter and one force, and a perfect uniformity throughout, is the most scientific and most likely to be true. An infinitesimal world, with the molecules and their atoms spinning and moving in orbits, in much the same manner as celestial bodies, carrying with them and probably spinning with them ether, or in other words, carrying with them static charges, seems to my mind the most probable view, and one which, in a plausible manner, accounts for most of the phenomena observed. The spinning of the molecules and their ether sets up ether tensions or electrostatic strains; the equalization of ether tensions sets up ether motions or electric currents, and the orbital movements produce the effects of electro and permanent magnetism.

About 15 years ago, Professor Rowland

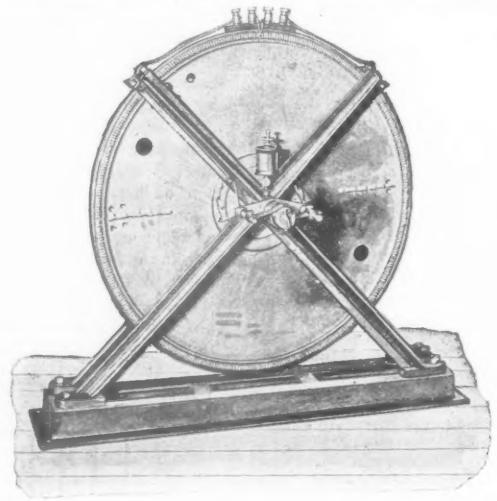


FIG. 1.—HIGH FREQUENCY ALTERNATOR WITH DRUM ARMATURE.

demonstrated a most interesting and important fact, namely, that a static charge carried around produces the effects of an electric current. Leaving out of consideration the precise nature of the mechanism which produces the attraction and repulsion of currents, and conceiving the electrostatically charged molecules in motion, this experimental fact gives us a fair idea of magnetism. We can conceive lines or tubes of force which physically exist, being formed of rows of directed moving molecules; we can see that these lines must be closed; that they must tend to shorten and expand, etc. It likewise explains in a reasonable way, the most puzzling phenomenon of all, permanent magnetism, and, in general, has all the beauties of the Ampere theory without possessing the vital defect of the same, namely, the assumption of molecular currents. Without enlarging further upon the subject, I would say, that I look upon all electrostatic, current and magnetic phenomena as being due to electrostatic molecular forces.

The preceding remarks I have deemed necessary to a full understanding of the subject as it presents itself to my mind.

Of all these phenomena the most important to study are the current phenomena, on account of the already extensive and ever-growing use of currents for industrial purposes. It is now a century since the first practical source of current has been produced, and, ever since, the phenomena which accompany the flow of currents have been diligently studied, and through the untiring efforts of scientific men the simple laws which govern them have been discovered. But these laws were found to hold good only when the currents are of a steady character. When the currents are rapidly varying in strength quite different phenomena, often unexpected, present themselves, and quite different laws hold good, which even now have not been determined as fully as is desirable, though through the work, principally, of English scientists, enough knowledge has been gained on the subject to enable us to treat simple cases, which now present themselves in daily practice.

The phenomena which are peculiar to the changing character of the currents are greatly exalted when the rate of change is increased, hence the study of these currents is considerably facilitated by the employment of properly constructed apparatus. It was with this and other objects in view that I constructed alternate current machines capable of giving more than two million reversals of current per minute, and to this circumstance it is principally due that I am able to bring to your attention some of the results thus far reached, which I hope will prove to be a step in advance on account of their direct bearing upon one of the most important problems, namely, the production of a practical and efficient source of light.

The study of such rapidly alternating currents is very interesting. Nearly every experiment discloses something new. Many results may, of course, be predicted, but many more are unforeseen. The experimenter makes many interesting observations. For instance, we take a piece of iron and hold it against a magnet. Starting from low alternations and running up higher and higher we feel the impulses succeed each other faster and faster, get weaker and weaker, and finally disappear. We then observe a continuous pull; the pull, of course, is not continuous; it only appears so to us: our sense of touch is imperfect.

We may next establish an arc between the electrodes and observe as the alternations rise, that the note which accompanies alternating arcs gets shriller and shriller, gradually weakens, and finally ceases. The air vibrations, of course, continue, but they are too weak to be perceived; our sense of hearing fails us.

We observe the small physiological effects, the rapid heating of the iron cores and conductors, curious inductive effects, interesting condenser phenomena and still more interesting light phenomena with a high tension induction coil. All these experiments and observations would be of the greatest interest to the student, but their description would lead me too far from the principal subject. Partly for this reason, and partly on account of the vastly greater importance, I will confine myself to the description of the light effects produced by these currents.

In the experiments to this end a high tension induction coil or equivalent apparatus for converting currents of comparatively low into currents of high tension is used.

If you will be sufficiently interested in the results I shall describe as to enter into an experimental study of this subject; if you will be convinced of the truth of the arguments I shall advance, your aim will be to produce high frequencies and high potentials; in other words, powerful electrostatic effects. You will then encounter many difficulties, which, if completely overcome, would allow us to produce truly wonderful results.

First will be met the difficulty of obtaining the required frequencies by means of mechanical apparatus, and, if they be obtained otherwise, obstacles of a different nature will present themselves. Next it will be found difficult to provide the requisite insulation without considerably increasing the size of the apparatus, for the potentials required are high, and owing to the rapidity of the alternations, the insulation presents peculiar difficulties. So, for instance, when a gas is present the discharge may work through by the molecular bombardment of the gas and consequent heating, through as much as an inch of the best solid insulating material, such as glass, hard rubber, porcelain, sealing wax, etc.; in fact, through any known insulating substance. The chief requisite in the insulation of the apparatus is, therefore, the exclusion of any gaseous matter.

In general my experience tends to show that bodies which possess the highest specific inductive capacity, such as glass, afford a rather inferior insulation to others, which, while they are good insulators, have a much smaller specific inductive capacity, such as oils, for instance, the dielectric losses being no doubt greater in the former. The difficulty of insulating, of course, only exists when the potentials are excessively high, for with potentials such as a few thousand volts there is no particular difficulty encountered in conveying currents from a machine giving, say, 20,000 alternations per second to quite a distance. This number of alternations, however, is by far too small for many purposes, though quite sufficient for some practical applications. This difficulty of insulating is fortunately not a vital drawback; it affects mostly the size of the apparatus, for, when excessively high potentials would be used, the light-giving devices would be located not far from the apparatus, and often they would be quite close to it. As the air bombardment of the insulated wire is dependent on condenser action, the loss may be reduced to a trifle by using excessively thin wires heavily insulated.

Another difficulty which will be encountered is the capacity and self induction necessarily possessed by the coil. If the coil be

large, that is, if it contains a great length of wire, it will be generally unsuited for excessively high frequencies; if it be small, it may be well adapted for such frequencies, but the potential might then not be as high as desired. A good insulator, and preferably

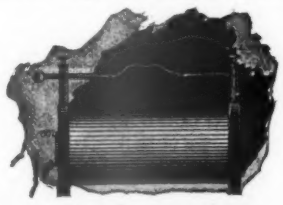


FIG. 4.—SENSITIVE THREAD DISCHARGE.

one possessing a small specific inductive capacity, would afford a two-fold advantage. First, it would enable us to construct a very small coil capable of withstanding enormous differences of potential; and secondly, such a small coil, by reason of its smaller capacity and self-induction, would be capable of a quicker and more vigorous vibration. The problem, then, of constructing a coil or induction apparatus of any kind possessing the requisite qualities I regard as one of no small importance, and it has occupied me for a considerable time.

The investigator who desires to repeat the experiments which I will describe, with an alterate current machine, capable of supplying currents of the desired frequency, and an induction coil, will do well to take the primary coil out and mount the secondary in such a manner as to be able to look through the tube upon which the secondary is wound. He will then be able to observe the streams which pass from the primary to the insulating tube, and from their intensity he will know how far he can strain the coil. Without this precaution he is sure to injure the insulation. This arrangement permits, however, an easy exchange of the primaries, which is desirable in these experiments.

The selection of the type of machine best suited for the purpose, must be left to the judgment of the experimenter. There are

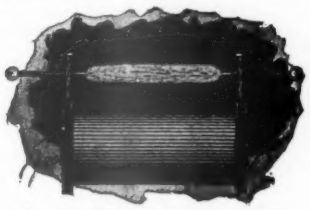


FIG. 5.—FLAMING DISCHARGE.

here illustrated three distinct types of machines, which, besides others, I have used in my experiments.

Fig. 1 represents the machine used in my experiments before this Institute. The field-magnet consists of a ring of wrought iron with 384 pole projections. The armature comprises a steel disk to which is fastened a thin, carefully welded rim of wrought iron. Upon the rim are wound several layers of fine, well annealed iron wire, which, when wound, is passed through shellac. The armature wires are wound around brass pins, wrapped with silk thread. The diameter of the armature wire in this type of machine should not be more than one-sixth of the thickness of the pole projections, else the local action will be considerable.

Fig. 2 represents a larger machine of a different type. The field-magnet of this machine consists of two like parts which either enclose an exciting coil, or else are independently wound. Each part has 480 pole projections, the projections of one facing those of the other. The armature consists of a wheel of hard bronze, carrying the conductors which revolve between the projections of the field-magnet. To wind the armature conductors, I have found it most convenient to proceed in the following manner: I construct a ring of hard bronze of

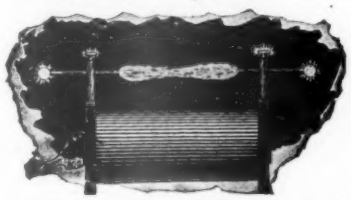


FIG. 6.—STREAMING DISCHARGE.

the required size. This ring and the rim of the wheel are provided with the proper number of pins, and both fastened upon a plate. The armature conductors being wound, the pins are cut off, and the ends of the conductors fastened by two rings which screw to the bronze ring and the rim of the wheel, respectively. The whole may then be taken off, and forms a solid structure. The conductors in such a type of machine should consist of sheet copper, the thickness of which, of course, depends on the thickness of the pole projections; or else twisted thin wires should be employed.

Fig. 3 is a smaller machine, in many respects similar to the former, only here the armature conductors and the exciting coil are kept stationary, while only a block of wrought iron is revolved.

It would be uselessly lengthening this description were I to dwell more on the details of construction of these machines. Besides, they have been described somewhat more elaborately in *The Electrical Engineer*, of March 18, 1891. I deem it well, however, to call the attention of the investigator to two things, the importance of which, though self-evident, he is nevertheless apt to underestimate; namely, to the local action in the conductors, which must be carefully avoided, and to the clear-

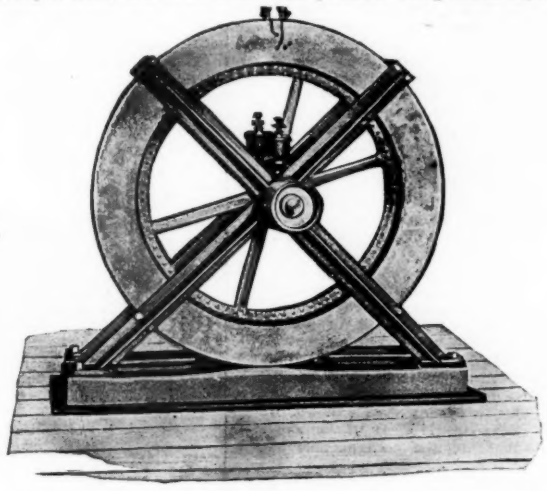


FIG. 2.—HIGH FREQUENCY ALTERNATOR WITH REVOLVING DISC ARMATURE.

ance, which must be small. I may add, that since it is desirable to use very high peripheral speeds, the armature should be of very large diameter in order to avoid impracticable belt speeds. Of the several types of these machines which have been constructed by me, I have found that the type illustrated in Fig. 1 caused me the least trouble in construction as well as in maintenance, and, on the whole, it has been a good experimental machine.

In operating an induction coil with very rapidly alternating currents, among the first luminous phenomena noticed are naturally those presented by the high tension discharge. As the number of alternations per second is increased, or as—the number being high—the current through the primary is varied, the discharge gradually changes in appearance. It would be difficult to describe

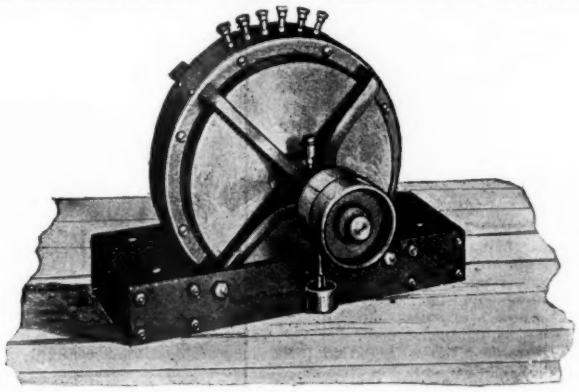


FIG. 3.—HIGH FREQUENCY ALTERNATOR WITH STATIONARY DISC ARMATURE AND STATIONARY EXCITING COIL.

the minor changes which occur and the conditions which bring them about, but one may note five distinct forms of the discharge.

First, one may observe a weak, sensitive discharge in the form of a thin feeble-colored thread. (Fig. 4.) It always occurs when the number of alternations per second being high, the current through the primary is very small. In spite of the excessively small current, the rate of change is great and the difference of potential at the terminals of the secondary is therefore considerable, so that the arc is established at great distances; but the quantity of "electricity" set in motion is insignificant, barely sufficient to maintain a thin, threadlike arc. It is excessively sensitive, and may be made so to such a degree that the mere act of breathing near the coil will affect it, and unless it is perfectly well protected from currents of air, it wriggles around constantly. Nevertheless, it is in this form excessively persistent, and when the terminals are approached to, say, one-third of the striking distance, it can be blown out only with difficulty. This exceptional persistency, when short, is largely due to the arc being excessively thin; presenting, therefore, a very small surface to the blast. Its great sensitiveness, when very long, is probably due to the motion of the particles of dust suspended in the air.

When the current through the primary is increased the discharge gets broader and stronger, and the effect of the capacity of the coil becomes visible until, finally, under proper conditions, a white flaming arc, Fig. 5, often as thick as one's finger and striking across the whole coil, is produced. It develops remarkable heat, and may be further characterized by the absence of the high note which accompanies the less powerful discharges. To take a shock from the coil under these conditions would not be advisable, although under different conditions, the potential being much higher, a shock from the coil may be taken with impunity. To produce this kind of discharge the number of alternations per second must not be too great for the coil used; and, generally speaking, certain relations between capacity, self-induction and frequency must be observed.

The importance of these elements in an alternate current circuit is now well known, and under ordinary conditions the general rules are applicable. But in an induction coil exceptional conditions prevail. First, the self-induction is of little importance before the arc is established, when it asserts itself, but perhaps never as prominently as in ordinary alternate current circuits, because capacity is distributed all along the coil, and by reason of the fact that the coil usually discharges through very great resistances; hence the currents are exceptionally small. Secondly, the capacity goes on increasing continually as the potential rises, in consequence of absorption, which takes place to a considerable extent. Owing to this there exists no critical relationship between these quantities, and ordinary rules would not seem to be applicable. As the potential is increased, either in consequence of the increased frequency or of the increased current through the primary, the amount of the energy stored becomes greater and greater and the capacity gains more and more in importance. Up to a certain point the capacity is beneficial, but after that it begins to be an enormous drawback. It follows from this that each coil gives the best result with a given frequency and primary current. A very large coil when operated with currents of very high frequency may not give as much as one-eighth inch spark. By adding capacity to the terminals the condition may be improved, but what the coil really wants is a lower frequency.

When the flaming discharge occurs the conditions are evidently such that the greatest current is made to flow through the circuit. These conditions may be attained by varying the frequency within wide limits, but the highest frequency at which the flaming arc can still be produced determines,

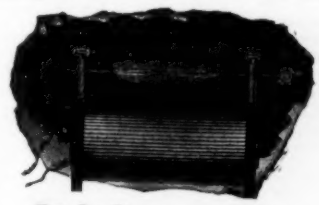


FIG. 7.—BRUSH AND SPRAY DISCHARGE.

for a given primary current, the maximum striking distance of the coil. In the flaming discharge the *éclat* effect of the capacity is not perceptible; the rate at which the energy is being stored then just equals the rate at which it can be disposed of through the circuit. This kind of discharge is the severest test for a coil; the break, when it occurs, is of the nature of that in an overcharged Leyden jar. To give a rough approximation I would state that, with an ordinary coil of, say 10,000 ohms resistance, the most powerful arc would be produced with about 12,000 alternations per second.

When the frequency is increased beyond that rate the potential, of course, rises, but the striking distance may, nevertheless, diminish, paradoxical as it may seem. As the potential rises the coil attains more and more the properties of a static machine until, finally, one may observe the beautiful phenomenon of the streaming discharge, Fig. 6, which may be produced across the whole length of the coil. At that stage streams begin to issue freely from all points and projections. These streams will also be seen to pass in abundance in the space between the primary and the insulating tube. When the potential is excessively high they will always appear, even if the frequency be low, and even if the primary be surrounded by as much as an inch of wax, hard rubber, glass or any other insulating substance.

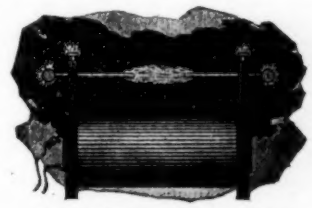


FIG. 8.—FIFTH TYPICAL FORM OF DISCHARGE.

This limits greatly the output of the coil, but I will later show how I have been able to overcome to a considerable extent this disadvantage in the ordinary coil.

Besides the potential, the intensity of the streams depends on the frequency; but if the coil be very large they show themselves, no matter how low the frequencies used. For instance, in a very large coil of resistance of 67,000 ohms, constructed by me some time ago, they appear with as low as 100 alternations per second and less, the insulation of the secondary being three-fourths inch of ebonite. When very intense they produce a noise similar to that produced by the charging of a Holtz machine, but much more powerful, and they emit a strong smell of ozone. The lower the frequency, the more apt they are to suddenly injure the coil. With excessively high frequencies they may pass freely without producing any other effect than to heat the insulation slowly and uniformly.

The existence of these streams shows the importance of constructing an expensive coil so as to permit of one's seeing through the tube surrounding the primary, and the latter

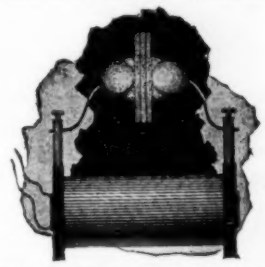


FIG. 9.—LUMINOUS DISCHARGE WITH INTERPOSED INSULATORS.

should be easily exchangeable; or else the space between the primary and secondary should be completely filled up with insulating material so as to exclude all air. The non-observance of this simple rule in the construction of the commercial coils is responsible for the destruction of many an expensive coil.

At the stage when the streaming discharge occurs, or with somewhat higher frequencies, one may, by approaching the terminals considerably and regulating properly the effect of capacity, produce a veritable spray of small silver-white sparks or a bunch of excessively thin silvery threads (Fig. 7) amidst a powerful brush—each spark or thread possibly corresponding to one alternation. This, when produced under proper conditions, is probably the most beautiful discharge, and when an air blast is directed against it, it presents a singular appearance. The spray of sparks, when received through the body, causes some inconvenience, where-

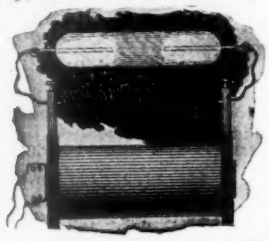


FIG. 10.—DISCHARGE THROUGH HIGHEST VACUUM.

as, when the discharge simply streams nothing at all is likely to be felt if large conducting objects are held in the hands to protect them from receiving small burns.

If the frequency is still more increased, then the coil refuses to give any spark unless at comparatively small distances, and the fifth typical form of discharge may be observed (Fig. 8). The tendency to stream out and dissipate is then so great that when the brush is produced at one terminal no sparking occurs even if, as I have repeatedly tried, the hand, or any conducting object, is held within the stream; and, what is more singular, the luminous stream is not at all easily deflected by the approach of a conducting body.

At this stage the streams seemingly pass with the greatest freedom through considerable thicknesses of insulators, and it is particularly interesting to study their behavior. For this purpose it is convenient to connect to the terminals of the coil two metallic spheres which may be placed at any desired distance (Fig. 9). Spheres are preferable to plates, as the discharge can be better observed. By inserting dielectric bodies between the spheres beautiful discharge phenomena may be observed. If the spheres be quite close and a spark be playing between them, by interposing a thin plate of ebonite between the spheres the spark instantly ceases and the discharge spreads into an intensely luminous circle several inches in diameter, provided the spheres are sufficiently large. The passage of the streams heats, and, after awhile, softens the rubber so much that two plates may be made to stick together in this manner. If the spheres are so far apart that no spark occurs, even if they are far beyond the striking distance, by inserting a thick plate of glass the discharge is instantly induced to pass from the spheres to the glass in the form of luminous streams. It appears almost as though these streams pass *through* the dielectric. In reality this is not the case, as the streams are due to the molecules of the air, which are violently agitated in the space between the oppositely charged surfaces of the spheres. When no dielectric other than air is present, the bombardment goes on, but is too weak to be visible; by inserting a dielectric the inductive effect is much increased, and, besides the projected air molecules find an obstacle and the bombardment becomes so intense that the streams become luminous.

If, by any mechanical means we could effect such a violent agitation of the molecules, we could produce the same phenomenon. A jet of air escaping through a

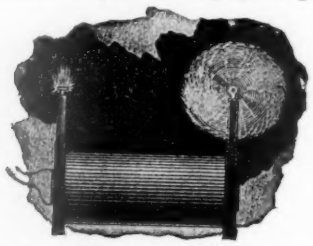


FIG. 11.—PINWHEEL DRIVEN BY A POWERFUL BRUSH.

small hole under enormous pressure and striking against an insulating substance, such as glass, may be luminous in the dark, and it might be possible to produce phosphorescence of the glass or other insulators in this manner.

The greater the specific inductive capacity of the interposed dielectric, the more powerful the effect produced. Owing to this, the streams show themselves with excessively high potentials, even if the glass be as much as one and one-half to two inches thick. But besides the heating due to bombardment, some heating goes on undoubtedly in the dielectric, being apparently greater in glass than in ebonite. I attribute this to the greater specific inductive capacity of the glass, in consequence of which, with the same potential difference, a greater amount of energy is taken up in it than in rubber. It is like connecting to a battery a copper and a brass wire of the same dimensions. The copper wire, though a more perfect conductor, would heat more by reason of its taking more current. Thus, what is otherwise considered a virtue of the glass is here a defect. Glass usually gives way much quicker than ebonite; when it is heated to a certain degree, the discharge suddenly breaks through at one point, assuming then the ordinary form of an arc.

The heating effect produced by molecular bombardment of the dielectric would, of course, diminish as the pressure of the air is increased, and at enormous pressures it would be negligible, unless the frequency would increase correspondingly.

It will be often observed in these experiments that when the spheres are beyond the striking distance, the approach of a glass plate, for instance, may induce the spark to jump between the spheres. This occurs when the capacity of the spheres is somewhat below the critical value which gives the greatest difference of potential at the terminals of the coil. By approaching a dielectric the specific inductive capacity of the space between the spheres is increased, producing the same effect as if the capacity of the spheres were increased. The potential at the terminals may then rise so high that the space is cracked. The experiment is best performed with dense glass or mica.

Another interesting observation is that a plate of insulating material, when the discharge is passing through it, is strongly attracted by either of the spheres, that is, by the nearer one, this being obviously due to the smaller mechanical effect of the bombardment on that side, and perhaps also to the greater electrification.

From the behavior of the dielectrics in these experiments we may conclude that the best insulator for these rapidly alternating currents would be the one possessing the smallest specific inductive capacity, and at the same time one capable of withstanding the greatest differences of potential; and

FIG. 12.—LUMINOUS STREAMS ESCAPING FROM A COTTON-COVERED WIRE.

thus two diametrically opposite ways of securing the required insulation are indicated, namely, to use either a perfect vacuum or a gas under great pressure; but the former would be preferable. Unfortunately, neither of these two ways is easily carried out in practice.

It is especially interesting to note the behavior of an excessively high vacuum in these experiments. If a test tube provided with external electrodes and exhausted to the highest possible degree be connected to the terminals of the coil, Fig. 10, the electrodes of the tube are instantly brought to a high temperature, and the glass at each end of the tube is rendered intensely phosphorescent, but the middle appears comparatively dark, and for a while remains cool.

When the frequency is so high that the discharge shown in Fig. 8 is observed, considerable dissipation no doubt occurs in the coil. Nevertheless, the coil may be worked for a long time, as the heating is gradual.

In spite of the fact that the difference of potential may be enormous, little is felt when the discharge is passed through the body, provided the hands are armed. This is to some extent due to the higher frequency, but principally to the fact that less energy is available externally, when the difference of potential reaches an enormous value, owing to the circumstance that with the rise of potential the energy absorbed in the coil increases as the square of the potential. Up to a certain point the energy available externally increases with the rise of potential, then it begins to fall off rapidly. Thus, with the ordinary high tension induction coil, the curious paradox exists that, while with a given current through the primary the shock might be fatal, with many times that current it might be perfectly harmless, even if the frequency be the same. With high frequencies and excessively high potentials when the terminals are not connected to bodies of some size, practically all the energy supplied to the primary is taken up by the coil. There is no breaking through, no local injury, but all the material, insulating and conducting, is uniformly heated.

To avoid misunderstanding in regard to the physiological effect of alternating currents of very high frequency, I think it necessary to state that while it is an undeniable fact that they are incomparably less dangerous than currents of low frequencies, yet it should not be thought that they are altogether harmless. What has just been said refers only to currents from an ordinary high tension induction coil, which currents are necessarily very small; if received directly from a machine or from a secondary of low resistance they produce more or less powerful effects and may cause serious injury, especially when used in conjunction with condensers.

The streaming discharge of a high tension induction coil differs in many respects from that of a powerful static machine. In color it has neither the violet of the positive nor the brightness of the negative static discharge, but lies somewhere between, being, of course, alternatively positive and negative. But since the streaming is more powerful when the point or terminal is electrified positively than when electrified negatively, it follows that the point of the brush is more like the positive, and the root more like the negative static discharge. In the dark, when the brush is very powerful, the root may appear almost white. The wind produced

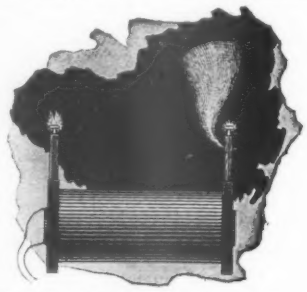


FIG. 13.—ASPECT PRESENTED BY A VERY THIN WIRE ATTACHED TO A TERMINAL OF THE COIL.

by the escaping streams, though it may be very strong—often indeed to such a degree that it may be felt quite a distance from the coil—is, nevertheless, considering the quantity of the discharge, smaller than that produced by the positive brush of a static machine, and it affects the flame much less powerfully. From the nature of the phenomenon we can conclude that the higher the frequency, the smaller must, of course, be the wind produced by the streams, and with sufficiently high frequencies no wind at all would be produced at the ordinary atmospheric pressures. With frequencies obtainable by means of a machine the mechanical effect is sufficiently great to revolve, with considerable speed, large pin-wheels, which in the dark present a beautiful appearance owing to the abundance of the streams (Fig. 11).

In general, most of the experiments usually performed with a static machine can be performed with an induction coil, when operated with very rapidly alternating cur-

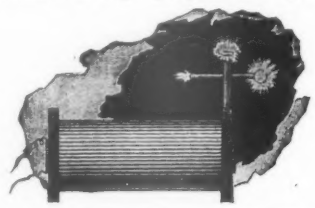


FIG. 14.—EFFECT OF BALL AND POINT.

rents. The effects produced, however, are much more striking, being of incomparably greater power. When a small length of ordinary cotton-covered wire (Fig. 12) is attached to one terminal of the coil, the streams issuing from all points of the wire may be so intense as to produce a considerable light effect. When the potentials and frequencies are very high, a wire insulated with gutta-percha or rubber, and attached to one of the terminals, appears to be covered with a luminous film. A very thin bare wire, when attached to a terminal, emits powerful streams, and vibrates continually to and fro, or spins in a circle, producing a singular effect (Fig. 13). Some of these experiments have been described by me in *The Electrical World* of February 21, 1891.

Another peculiarity of the rapidly alternating discharge of the induction coil is its radically different behavior with respect to points and rounded surfaces.

If a thick wire, provided with a ball at one end, and with a point at the other, be attached to the positive terminal of a static machine, practically all the charge will be lost through the point, on account of the enormously greater tension dependent on the radius of curvature. But if such a wire is attached to one of the terminals of the induction coil, it will be observed that with very high frequencies streams issue from the ball almost as copiously as from the point (Fig. 14).

It is hardly conceivable that we could produce such a condition to an equal degree in a static machine, for the simple reason that the tension increases as the square of the density, which in turn is proportional to the radius of curvature; hence, with a steady potential an enormous charge would be required to make streams issue from a polished ball while it is connected with a point. But with an induction coil the discharge of which alternates with great rapidity, it is different. Here we have to deal with two distinct ten-

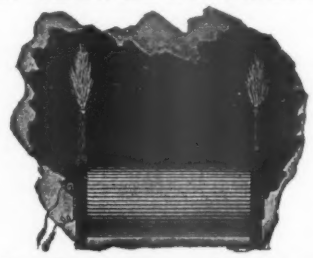


FIG. 15.—ASPECT OF COIL UNDER POWERFUL BRUSH DISCHARGE.

dencies. First, there is the tendency to escape, which exists in a condition of rest and which depends on the radius of curvature; second, there is the tendency to dissipate into the surrounding air by condenser action, which depends on the surface. When one of these tendencies is a maximum, the other is at a minimum. At the point the luminous stream is principally due to the air molecules coming bodily in contact with the point; they are attracted and repelled, charged and discharged, and, their atomic charges being thus disturbed, vibrate and emit light waves. At the ball, on the contrary, there is no doubt that the effect is to a great extent produced inductively, the air molecules not *necessarily* coming in contact with the ball, though they undoubtedly do so. To convince ourselves of this we only need to exalt the condenser action, for instance, by enveloping the ball, at some distance, by a better conductor than the surrounding medium, the conductor being, of course, insulated; or else by surrounding it with a better dielectric and approaching an insulated conductor; in both cases the streams will break forth more copiously. Also, the larger the ball with a given frequency, or the higher the frequency, the more will the ball have the advantage over the point. But, since a certain intensity of action is required to render the stream visible, it is obvious that in the experiment described the ball should not be taken too large.

In consequence of this two-fold tendency it is possible to produce by means of points, effects identical to those produced by capacity. Thus, for instance, by attaching to one terminal of the coil a small length of coiled wire, presenting many points and offering great facility to escape, the potential of the coil may be raised to the same value as by attaching to the terminal a polished ball of a surface many times greater than that of the wire.

An interesting experiment showing the effect of the points may be performed in the following manner: Attach to one of the terminals of the coil a cotton covered wire about two feet in length and adjust the conditions so that streams issue from the wire. In this experiment the primary coil should be preferably placed so that it extends only about half-way into the secondary coil. Now touch the free terminal of the secondary with a conducting object held in the hand, or else connect it to an insulated body of some size. In this manner the potential on the wire may be enormously raised.

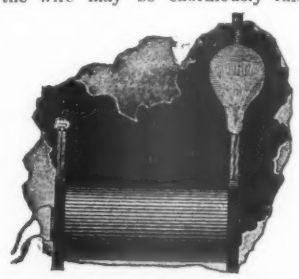


FIG. 16.—INCANDESCENT WIRE OR FILAMENT SPINNING IN AN UNEXHAUSTED GLOBE.

The effect of this will be to either increase or to diminish the streams. If they increase, the wire is too short; if they diminish, it is too long. By adjusting the length of the wire a point is found where the touching of the other terminal does not at all affect the streams. In this case the rise of potential is exactly counteracted by the drop through the coil. It will be observed that small lengths of wire produce considerable difference in the magnitude and luminosity of the streams. The primary coil is placed sidewise for two reasons: First, to increase

the potential at the wire and, second, to increase the drop through the coil. The sensitiveness is thus augmented.

There is still another and far more striking peculiarity of the brush discharge produced by very rapidly alternating currents. To observe this it is best to replace the usual terminals of the coil by two metal columns insulated with a good thickness of ebonite. It is also well to close all fissures and cracks with wax so that the brushes cannot form

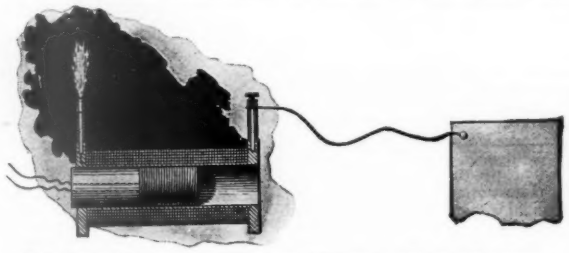


FIG. 17A.—COIL ARRANGED FOR POWERFUL BRUSH EFFECTS.

anywhere except at the tops of the columns. If the conditions are carefully adjusted—which, of course, must be left to the skill of the experimenter—so that the potential rises to an enormous value, one may produce two powerful brushes several inches long, nearly white at their roots, which in the dark bear a striking resemblance to two flames of a gas escaping under pressure (Fig. 15). But they do not only *resemble*, they *are* veritable flames, for they are hot. Certainly they are not as hot as a gas burner, *but they would be so if the frequency and the potential would be sufficiently high.* Produced with, say, 20,000 alternations per second, the heat is easily perceptible, even if the potential is not excessively high. The heat developed is, of course, due to the impact of the air molecules against the terminals and against each other. As, at the ordinary pressures, the mean free path is excessively small, it is possible that in spite of the enormous initial

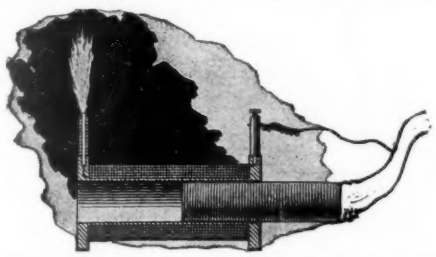


FIG. 17B.—COIL ARRANGED FOR POWERFUL BRUSH EFFECTS.—ST. ELMO'S HOT FIRE.

speed imparted to each molecule upon coming in contact with the terminal, its progress—by collision with other molecules—is retarded to such an extent, that it does not get away far from the terminal, but may strike the same many times in succession. The higher the frequency the less the molecule is able to get away, and this the more so, as for a given effect the potential required is smaller; and a frequency is conceivable—perhaps, even obtainable—at which practically the same molecules would strike the terminal. Under such conditions the exchange of the molecules would be very slow and the heat produced at and very near the terminal would be excessive. But if the frequency would go on increasing constantly, the heat produced would begin to diminish for obvious reasons. In the positive brush of a static machine the exchange of the molecules is very rapid, the stream is constantly of one direction, and there are fewer collisions; hence, the heating effect must be very small. Anything that impairs

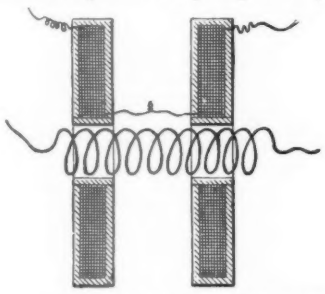


FIG. 18.—COIL FOR PRODUCING VERY HIGH DIFFERENCE OF POTENTIAL.

the facility of exchange tends to increase the local heat produced. Thus, if a bulb be held over the terminal of the coil so as to enclose the brush, the air contained in the bulb is very quickly brought to a high temperature. If a glass tube be held over the brush so as to allow the draught to carry the brush upwards, scorching hot air escapes at the top of the tube. Anything held within the brush is, of course, rapidly heated, and the possibility of using such heating effects for some purpose or other suggests itself.

When contemplating this singular phenomenon of the hot brush, we cannot help being convinced that a similar process must take place in the ordinary flame, and it seems strange that after all these centuries past of familiarity with the flame, now, in this era of electric lighting and heating, we are finally led to recognize, that since time immemorial we have, after all, always had "electric light and heat" at our disposal. It is also of no little interest to contemplate that we have a possible way of producing—by other than chemical means—a veritable flame, which would give light and heat without any material being consumed, without any chemical process taking place, and to accomplish this, we only need to perfect methods of producing enormous frequencies and potentials. I have no doubt that if the potential could be made to alternate with sufficient rapidity and power, the brush formed at the end of a wire would lose its electrical characteristics and would become flamelike. The flame must be due to electrostatic molecular action.

This phenomenon now explains in a manner which can hardly be doubted the frequent accidents occurring in storms. It is well known that objects are often set on fire without the lightning striking them. We shall presently see how this can happen. On a nail in a roof, for instance, or on a projection of any kind, more or less conducting or rendered so by dampness, a powerful brush may appear. If the lightning strikes somewhere in the neighborhood the enormous potential may be made to alternate or fluctuate, perhaps, many million times a second. The air molecules are violently attracted and repelled, and by their impact produce such a powerful heating effect that a fire is started. It is conceivable that a ship at sea may, in this manner, catch fire at many points at once. When we consider that even with the comparatively low frequencies obtained from a dynamo machine and with potentials of no more than one or two hundred thousand volts the heating effects are considerable, we may imagine how much more powerful they must be with frequencies and potentials many times greater, and the above explanation seems, to say the least, very probable. Similar explanations may have been suggested, but I am not aware that up to the present the heating effects of a brush produced by a rapidly alternating potential have been experimentally demonstrated, at least not to such a remarkable degree.

By preventing completely the exchange of the air molecules the local heating effect may be so exalted as to bring a body to incandescence. Thus, for instance, if a small button or, preferably, a very thin wire or filament be enclosed in an unexhausted globe and connected with the terminal of the coil, it may be rendered incandescent. The phenomenon is made much more interesting by the rapid spinning round in a circle of the top of the filament, thus presenting the appearance of a luminous funnel, Fig. 16, which widens when the potential is increased. When the potential is small the end of the filament may perform irregular motions, suddenly changing from one to the other, or it may describe an ellipse; but when the potential is very high it always spins in a circle; and so does generally a thin straight wire attached freely to the terminal of the coil. These motions are, of course, due to the impact of the molecules and the irregularity in the distribution of the potential owing to the roughness and dissymmetry of the wire or filament. With a perfectly symmetrical and polished wire such motions would probably not occur. That the motion is not likely to be due to other causes is evident from the fact that it is not of a definite direction and that in a very highly exhausted globe it ceases altogether. The possibility of bringing a body to incandescence in an unexhausted globe, or even when not at all enclosed, would seem to afford a possible way of obtaining lighter effects, which in perfecting methods of producing rapidly alternating potentials might be rendered available for useful purposes.

In employing a commercial coil, the production of very powerful brush effects is attended with considerable difficulties, for when these high frequencies and enormous potentials are used, the best insulation is apt to give way. Usually the coil is insulated well enough to stand the strain from convolution to convolution, since two double silk-covered paraffined wires will withstand a pressure of several thousand volts; the difficulty lies, principally, in preventing the breaking through from the secondary to the primary, which is greatly facilitated by the streams issuing from the latter. In the coil, of course, the strain is greatest from section to section, but usually in a larger coil there are so many sections that the danger of a sudden giving way is not very great. No difficulty will generally be encountered in that direction, and, besides, the liability of injuring the coil internally is very much reduced by the fact that the effect most likely to be produced is simply a gradual heating, which, when far enough advanced, could not fail to be observed. The principal necessity is, then, to prevent the streams between the primary and the tube, not only on account of the heating and possible injury, but also because the streams may diminish very considerably the potential difference available at the terminals. A few hints as to how this may be accomplished will probably be found useful in most of these experiments with the ordinary induction coil.

One of the ways is to wind a short primary (Fig. 17 A) so that the difference of potential is not at that length great enough to cause the breaking forth of the streams through the insulating tube. The length of the primary should be determined by experiment. Both the ends of the coil should be brought out on one end through a plug of insulating material fitting in the tube as illustrated. In such a disposition one terminal of the secondary is attached to a body, the surface of which is determined with the greatest care, so as to produce the greatest rise in the potential. At the other terminal a powerful brush appears, which may be experimented upon.

The above plan necessitates the employment of a primary of comparatively small size, and it is apt to heat when powerful effects are desirable for a certain length of time. In such a case it is better to employ a larger coil (Fig. 17 B), and introduce it from one side of the tube, until the streams begin to appear. In this case the nearest terminal of the secondary may be connected to the primary or to the ground, which is practically the same thing, if the primary is connected directly to the machine. In the case of ground connections it is well to determine experimentally the frequency which is best suited under the conditions of the test. Another way of obviating the streams, more or less, is to make the primary in sections, and supply it from separate well-insulated sources.

In many of these experiments, when powerful effects are wanted for a short time, it is advantageous to use iron cores with the primaries. In such case a very large primary coil may be wound and placed side by side with the secondary, and, the nearest terminal of the latter being connected to the primary, a laminated iron core is introduced through the primary into the secondary as far as the streams will permit. Under these conditions an excessively powerful brush, several inches long, which may be appropriately called "St. Elmo's hot fire," may be caused to appear at the other terminal of the secondary, producing striking effects. It is a most powerful ozonizer, so powerful indeed, that only a few minutes are sufficient to fill the whole room with the smell of ozone, and it undoubtedly possesses the quality of exciting chemical affinities.

For the production of ozone, alternating currents of very high frequency are eminently suited, not only on account of the advantages they offer in the way of conversion, but also because of the fact that the ozonizing action of a discharge is dependent on the frequency as well as on the potential, this being undoubtedly confirmed by observation.

In these experiments if an iron core is used it should be carefully watched, as it is apt to get excessively hot in an incredibly short time. To give an idea of the rapidity of the heating, I will state, that by passing a powerful current through a coil with many turns, the inserting within the same of a thin iron wire for no more than one second's time is sufficient to heat the wire to something like 100° C.

But this rapid heating does not need to discourage us in the use of iron cores in connection with rapidly alternating currents. I have for a long time been convinced, that in the industrial distribution by means of transformers, some such plan as the following might be practicable. We may use a comparatively small iron core, subdivided, or perhaps not even subdivided. We may surround this core with a considerable thickness of material which is fire-proof and conducts the heat poorly, and on top of that we may place the primary and secondary windings. By using either higher frequencies or greater magnetizing forces, we may by hysteresis and eddy currents heat the iron core so far as to bring it nearly to its maximum permeability, which, as Hopkinson has shown, may be as much as 10 times greater than that at ordinary temperatures. If the iron core were perfectly enclosed it would not be deteriorated by the heat, and if the enclosure of fire-proof material would be sufficiently thick, only a limited amount of energy could be radiated in spite of the high temperature. Transformers have been constructed by me on that plan, but for lack of time no thorough tests have as yet been made.

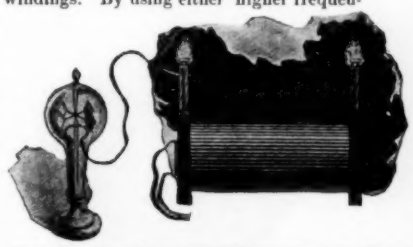


FIG. 19.—THE CROOKES EXPERIMENT ON OPEN CIRCUIT.

Another way of adapting the iron core to rapid alternations, or generally speaking, reducing the frictional losses, is to produce by continuous magnetization a flow of something like 7,000 or 8,000 lines per square centimetre through the core and then work with weak magnetizing forces and preferably high frequencies around the point of greatest permeability. A higher efficiency of conversion and greater output are obtainable

FIG. 20.—LAMP WITH SINGLE BLOCK OF REFRACTORY MATERIAL.

in this manner. I have also employed this principle in connection with machines in which there is no reversal of polarity. In these types of machines, as long as there are only few pole projections, there is no great gain, as the maxima and minima of magnetization are far from the point of maximum permeability; but when the number of the pole projections is very great, the required rate of change may be obtained without the magnetization varying so far as to depart greatly from the point of maximum permeability, and the gain is considerable.

The above described arrangements refer only to the use of commercial coils as ordinarily constructed. If it is desired to construct a coil for the express purpose of performing with it such experiments as I have described, or, generally, rendering it capable of withstanding the greatest possible difference of potential, then a construction as indicated in Fig. 18 will be found of advantage. The coil in this case is formed of two independent parts, which are wound oppositely, the connection between both being made near the primary. The potential in the middle being zero, there is not much tendency to jump to the primary and not much insulation is required. In some cases the middle point may, however, be connected to the primary or to the ground. In such a

FIG. 21.—LAMP WITH TWO FILAMENTS IN HIGHEST VACUUM WITH LEADING-IN WIRES.

coil the places of greatest difference of potential are far apart and the coil is capable of withstanding an enormous strain. The two parts may be movable so as to allow a slight adjustment of the capacity effect.

As to the manner of insulating the coil, it will be found convenient to proceed in the following way: First the wire should be boiled in paraffine until all the air is out; then the coil is wound by running the wire through the melted paraffine, merely for the

FIG. 22.—LAMP WITH TWO REFRACTORY BLOCKS IN HIGHEST VACUUM.

purpose of fixing the wire. The coil is then taken off from the spool, immersed in a cylindrical vessel filled with pure melted wax and boiled for a long time until the bubbles cease to appear. The whole is then left to cool down thoroughly, and then the mass is taken out of the vessel and turned up in a lathe. The coil made in this manner and with care is capable of withstanding enormous potential differences.

It may be found convenient to immerse the coil in paraffine oil or some other kind of oil; it is a most effective way of insulating, principally on account of the perfect exclusion of air, but it may be found that after all a vessel filled with oil is not a very convenient thing to handle in a laboratory.

If an ordinary coil can be dismounted, the primary may be taken out of the tube and the latter plugged up on one end, filled with oil, and the primary re-inserted. This affords an excellent insulation and prevents the formation of the streams.

Of all the experiments which may be performed with rapidly alternating currents the most interesting are those which concern the production of a practical illuminant. It cannot be denied that the present methods, though they were brilliant advances, are very wasteful. Some better methods must be invented, some more perfect apparatus devised. Modern research has opened new possibilities for the production of an efficient source of light, and the attention of all has been turned in the direction indicated by able pioneers. Many have been carried away by the enthusiasm and passion to discover, but in their zeal to reach results many have been misled. Starting with the idea of producing electromagnetic waves, they turned their attention, perhaps, too much to the study of electromagnetic effects and neglected the study of electrostatic phenom-

FIG. 23.—LAMP WITH SINGLE STRAIGHT FILAMENT AND ONE LEADING-IN WIRE.

ena. Naturally, nearly every investigator availed himself of an apparatus similar to that used in earlier experiments. But in those forms of apparatus, while the electromagnetic inductive effects are enormous, the electrostatic effects are excessively small.

In the Hertz experiments, for instance, a high tension induction coil is short circuited by an arc, the resistance of which is very small; the smaller, the more capacity is attached to the terminals, and the difference of potential at these is enormously diminished. On the other hand, when the discharge is not passing between the terminals the static effects may be considerable, but only qualitatively so, not quantitatively, since their rise and fall is very sudden and since their frequency is small. In neither case, therefore, are powerful electrostatic effects perceivable. Similar conditions exist when, as in some interesting experiments of Dr. Lodge, Leyden jars are discharged disruptively. It has been thought—and I believe asserted—that in such cases most of the energy is radiated into space. In the light of the experiments which I have described above, it will now not be thought so. I feel safe in asserting that in such cases most of the energy is partly taken up and converted into heat in the arc of the discharge and in the conducting and insulating material of the jar, some energy being, of course, given off by electrification of the air; but the amount of the directly radiated energy is very small.

When a high tension induction coil, operated by currents alternating only 20,000 times a second, has its terminals closed through even a very small jar, practically all the energy passes through the dielectric of the jar, which is heated, and the electrostatic effects manifest themselves outwardly only to a very weak degree. Now, the external circuit of a Leyden jar, that is, the arc and the connections of the coatings, may be looked upon as a circuit generating alternating currents of excessively high frequency and fairly high potential, which is closed through the coatings and the dielectric between them, and from the above it is evident that the external electrostatic effects must be very small, even if a recoil circuit be used. These conditions make it appear that with the apparatus usually at hand the observation of powerful electrostatic effects was impossible, and what experience has been gained in that direction is only due to the great ability of the investigators.

But powerful electrostatic effects are *sine qua non* of light production on the lines indicated by theory. Electromagnetic effects are primarily unavailable, for the reason that

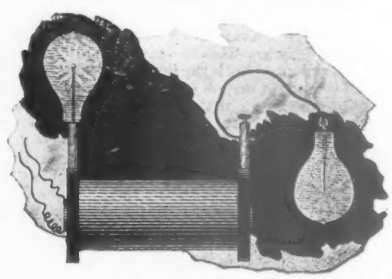


FIG. 24.—LAMPS WITH ONE LEADING-IN WIRE RENDERED INCANDESCENT.

to produce the required effects we would have to pass current impulses through a conductor which, long before the required frequency of the impulses could be reached, would cease to transmit them. On the other hand, electromagnetic waves many times longer than those of light and producible by sudden discharges of a condenser could not be utilized, it would seem, except we avail ourselves of their effect upon conductors, as in the present methods, which are wasteful. We could not effect by means of such waves the static molecular or atomic charges of a gas, cause them to vibrate and to emit light. Long transverse waves cannot, apparently, produce such effects, since excessively small electromagnetic disturbances may pass readily through miles of air. Such dark waves, unless they are of the length of true light waves, cannot, it would seem, excite luminous radiation in a Geissler tube, and the luminous effect, which are producible by induction in a tube devoid of electrodes, I am inclined to consider as being of an electrostatic nature.

To produce such luminous effects straight electrostatic thrusts are required; these, whatever be their frequency, may disturb the molecular charges and produce light. Since current impulses of the required frequency cannot pass through a conductor of measurable dimensions, we must work with a gas and then the production of powerful electrostatic effects becomes an imperative necessity.

It has occurred to me, however, that electrostatic effects are in many ways available for the production of light. For instance, we may place a body of some refractory material in a closed, and preferably more or less exhausted, globe, connect it to a source of high, rapidly alternating potential, causing the molecules of the gas to strike it many times a second at enormous speeds, and in this manner, with trillions of invisible hammers, pound it until it gets incandescent; or, we may place a body in a very highly exhausted globe, in a non-striking vacuum, and by employing very high frequencies and potentials, transfer sufficient energy from it to other bodies in the vicinity or in general to the surroundings, to maintain it at any degree of incandescence; or, we may, by means of such rapidly alternating high potentials, disturb the ether carried by the molecules of a gas or their static charges, cause them to vibrate and to emit light.

But electrostatic effects being dependent upon the potential and frequency, to produce the most powerful action, it is desirable to increase both as far as practicable. It may be possible to obtain quite fair results by keeping either of these factors small, provided the other is sufficiently great; but we are limited in both directions. My experience demonstrates that we cannot go below a certain frequency, for, first, the potential then becomes so great that it is dangerous; and, secondly, the light production is less efficient.

I have found that, by using the ordinary low frequencies, the physiological effect of the current required to maintain at a certain degree of brightness a tube four feet long, provided at the ends with outside and inside condenser coatings, is so powerful that, I think, it might produce serious injury to those not accustomed to such shocks; whereas, with 20,000 alternations per second the tube may be maintained at the same degree of brightness without any effect being felt. This is due principally to the fact that a much smaller potential is required to produce the same light effect, and also to the higher efficiency in the light production. It is evident that the efficiency in such cases is the greater, the higher the frequency, for the quicker the process of charging and discharging the molecules, the less energy will be lost in the form of dark radiation. But, unfortunately, we cannot go beyond a certain frequency on account of the difficulty of producing and conveying the effects.

I have stated above that a body enclosed in an unexhausted bulb may be intensely heated by simply connecting it with a source of rapidly alternating potential. The heating in such a case is, in all probability, due mostly to the bombardment of the molecules of the gas contained in the bulb. When the

FIG. 25.—LAMP WITH TWO BLOCKS OR FILAMENTS AND A PAIR OF INDEPENDENT INSIDE AND OUTSIDE CONDENSER COATINGS.

bulb is exhausted the heating of the body is much more rapid and there is no difficulty whatever in bringing a wire or filament to any degree of incandescence by simply connecting it to one terminal of a coil of the proper dimensions. Thus, if the well-known apparatus of Professor Crookes, consisting of a bent platinum wire with vanes mounted over it (Fig. 19), be connected to one terminal

FIG. 26A.

FIG. 26B.

LAMP WITH ONE FILAMENT, ONE INSIDE AND ONE OUTSIDE CONDENSER COATING.

of the coil—either one or both ends of the platinum wire being connected—the wire is rendered almost instantly incandescent and the mica vanes are rotated as though a current from a battery were used. A thin carbon filament, or, preferably, a button of some refractory material (Fig. 20), even if it be a comparatively poor conductor, enclosed in an exhausted globe, may be rendered highly incandescent; and in this manner a simple lamp capable of giving any desired candle-power is provided.

The success of lamps of this kind would depend largely on the selection of the light-giving bodies contained within the bulb. Since, under the conditions described, refractory bodies—which are very poor conductors and capable of withstanding for a long time excessively high degrees of temperature—may be used, such illuminating devices may be rendered successful.

It might be thought at first that if the

FIG. 27.—LAMP WITH ONE FILAMENT AND LEADING-IN WIRE AND EXTERNAL CONDENSER COATING.

bulb containing the filament or button of refractory material, be perfectly well exhausted—that is, as far as it can be done by the use of the best apparatus—the heating would be much less intense, and that in perfect vacuum it could not occur at all. This is not confirmed by my experience; quite the contrary, the better the vacuum the easier the bodies are brought to incandescence. This result is interesting for many reasons.

At the outset of this work the idea presented itself to me, whether two bodies of refractory material enclosed in a bulb exhausted to such a degree that the discharge of a large induction coil operated in the usual manner cannot pass through, could be rendered incandescent by mere condenser action. Obviously, to reach this result enormous potential differences and very high frequencies are required, as is evident from a simple calculation.

But such a lamp would possess a vast advantage over an ordinary incandescent lamp in regard to efficiency. It is well known that the efficiency of a lamp is to some extent a function of the degree of incandescence and that could we but work a filament at many times higher degrees of incandescence the efficiency would be much greater. In an ordinary lamp this is impracticable on account of the destruction of the filament, and it has been determined by experience how far it is advisable to push the incandescence. It is impossible to tell how much higher efficiency could be obtained if the filament could withstand indefinitely, as the investigation to this end obviously cannot be carried beyond a certain stage; but there are reasons for believing that it would be very considerably higher. An improvement might be made in the ordinary lamp by employing a short and thick carbon; but then the leading-in wires would have to be thick, and, besides, there are many other considerations which render such a modification entirely impracticable. But in a lamp as above described, the leading-in wires may be very small, the incandescent refractory material may be in the shape of blocks offering a very small radiating surface, so that less energy would be required to keep them at the desired incandescence; and in addition to this the refractory material need not be carbon, but may be manufactured from mixtures of oxides, for instance, with carbon or other material, or may be selected from bodies which are practically non-conductors and capable of withstanding enormous degrees of temperature.

All this would point to the possibility of obtaining a much higher efficiency with such a lamp than is obtainable in ordinary lamps. In my experience it has been demonstrated that the blocks are brought to high degrees of incandescence with much lower potentials than those determined by calculation, and the blocks may be set at greater dis-

tances from each other. We may freely assume, and it is probable, that the molecular bombardment is an important element in the heating even if the globe be exhausted with the utmost care, as I have done; for although the number of the molecules is, comparatively speaking, insignificant, yet on account of the mean free path being very great there are fewer collisions and the molecules may reach much higher speeds, so that the heating effect due to this cause may be considerable, as in the Crookes experiments with radiant matter.

But it is likewise possible that we have to deal here with an increased facility of los-

FIG. 28.—LAMP WITH ONE FILAMENT, ONE INSIDE AND ONE OUTSIDE CONDENSER COATING AND AUXILIARY COATING.

ing the charge in very high vacuum, when the potential is rapidly alternating, in which case most of the heating would be directly due to the surging of the charges in the heated bodies. Or else the observed fact may be largely attributable to the effect of the points which I have mentioned above, in consequence of which the blocks or filaments contained in the vacuum are equivalent to condensers of many times greater surface than that calculated from their geometrical dimensions. Scientific men still differ in opinion as to whether a charge should, or should not, be lost in a perfect vacuum; or, in other words, whether ether is, or is not, a conductor. If the former were the case, then a thin filament enclosed in a perfectly exhausted globe, and connected to a source of enormous, steady potential, would be brought to incandescence.

Various forms of lamps on the above described principle, with the refractory bodies in the form of filaments, Fig. 21, or blocks, Fig. 22, have been constructed and operated by me, and investigations are being carried on in this line. There is no difficulty in reaching such high degrees of incandescence that ordinary carbon is to all appearance melted and volatilized. If the vacuum could be made absolutely perfect, such a lamp, although inoperative with apparatu ordinarily used, would, if operated with currents of the required character, afford an illuminant which would never be destroyed, and which would be far more efficient than an ordinary incandescent lamp. This perfection can, of course, never be reached, and a very slow destruction and gradual diminution of the size always occurs, as in incandescent lamps; but there is no possibility of a sudden and premature disabling, which occurs in the latter by the breaking of the filament, especially when the incandescent bodies are in the shape of blocks.

With these rapidly alternating potentials there is, however, no necessity of enclosing two blocks in a globe, but a single block, as in Fig. 20, or filament, Fig. 23, may be used. The potential in this case must, of course, be higher, but it is easily obtainable, and besides it is not necessarily dangerous.

The facility with which the button or filament in such a lamp is brought to incandescence, other things being equal, depends on the size of the globe. If a perfect vacuum could be obtained the size of the globe would not be of importance, for then the heating would be wholly due to the surging of the charges, and all the energy would be given off to the surroundings by radiation. But this can never occur in practice. There is always some gas left in the globe, and although the exhaustion may be carried to the highest degree, still the space inside of the bulb must be considered as conducting when such high potentials are used; and I assume that in estimating the energy that may be given off from the filament to the surroundings, we may consider the inside surface of the bulb as one coating of a condenser, the air and other objects surrounding the bulb forming the other coating. When the alternations are very low, there is no doubt that a considerable portion of the energy is given off by the electrification of the surrounding air.

In order to study this subject better, I carried on some experiments with excessively high potentials and low frequencies. I then observed that when the hand is approached to the bulb—the filament being connected with one terminal of the coil—a powerful vibration is felt, being due to the attraction and repulsion of the molecules of the air, which are electrified by induction through the glass. In some cases, when the action is very intense, I have been able to hear a sound, which must be due to the same cause.

When the alternations are low, one is apt to get an excessively powerful shock from the bulb. In general, when one attaches bulbs or objects of some size to the terminals of the coil, one should look out for the rise of potential, for it may happen that by merely connecting a bulb or plate to the terminal, the potential may rise to many times its original value. When lamps are attached to the terminals, as illustrated in Fig. 24, then the capacity of the bulbs should be such as to give the maximum rise of potential under the existing conditions. In this manner one may obtain the required potential with fewer turns of wire.

The life of such lamps, as described above, depends, of course, largely on the degree of exhaustion, but to some extent also on the shape of the block of refractory material. Theoretically it would seem that a small sphere of carbon enclosed in a sphere of glass would not suffer deterioration from molecular bombardment, for the matter in the globe, being radiant, the molecules would move in straight lines and would seldom strike the sphere obliquely. An interesting thought in connection with such a lamp is, that in it "electricity" and electrical energy apparently must move in the same lines.

The use of alternating currents of very high frequency makes it possible to transfer by electrostatic or electromagnetic induction through the glass of a lamp sufficient energy to keep a filament at incandescence and so do away with the leading-in wires. Such lamps have been proposed, but for want of proper apparatus they have not been successfully operated. Many forms of lamps on this principle with continuous and broken filaments have been constructed by me and experimented upon. When using a secondary enclosed within the lamp a condenser is advantageously combined with the secondary. When the transference is effected by electrostatic induction the potentials used are, of course, very high with frequencies obtainable from a machine. For instance, with a condenser surface of 40 centimeters square, which is not impracticably large, and with glass of good quality 1 mm. thick, using currents alternating 20,000 times a second, the potential required is approximately 9,000 volts. This may seem large, but since each lamp may be included in the secondary of a transformer of very small dimensions, it would not be inconvenient, and, moreover, it would not produce fatal injury. The transformers would all be preferably in series. The regulation would offer no difficulties, as with currents of such frequencies it is very easy to maintain a constant current.

In the accompanying engravings some of the types of lamps of this kind are shown. Fig. 25 is such a lamp with a broken filament, and Fig. 26A and 26B one with a single outside and inside coating and a single filament. I have also made lamps with two outside and inside coatings and a continuous loop connecting the latter. Such lamps have been operated by me with current impulses of the enormous frequencies obtainable by the disruptive discharge of condensers.

The disruptive discharge of a condenser is especially suited for operating such lamps—with no outward electrical connections—by means of electromagnetic induction, the electromagnetic inductive effects being excessively high; and I have been able to produce the desired incandescence with only a few short turns of wire. Incandescence may also be produced in this manner in a simple closed filament.

Leaving, now, out of consideration the practicability of such lamps, I would only say that they possess a beautiful and desirable feature, namely, that they can be rendered, at will, more or less brilliant simply by altering the relative position of the outside and inside condenser coatings or inducing and induced circuits.

When a lamp is lighted by connecting it to one terminal only of the source this may be facilitated by providing the globe with an outside conductive coating, which serves at the same time as a reflector, and connecting this to an insulated body of some size. Lamps of this kind are illustrated in Fig. 27 and Fig. 28. Fig. 29 shows the plan of connections. The brilliancy of the lamp may, in this case, be regulated within wide limits by varying the size of the insulated metal plate to which the coating is connected.

It is likewise practicable to light with one leading wire lamps such as illustrated in Fig. 21 and Fig. 22, by connecting one terminal of the lamp to one terminal of the source and the other to an insulated body of the required size. In all cases the insulated body serves to give off the energy into the surrounding space, and is equivalent to a return wire. Obviously, in the two last-named cases, instead of connecting the wires to an insulated body, connections may be made to the ground.

The experiments which will prove most suggestive and of most interest to the investigator are probably those performed with exhausted tubes. As might be anticipated, a source of such rapidly alternating potentials is capable of exciting the tubes at a considerable distance and the light effects produced are remarkable.

During my investigations in this line I endeavored to excite tubes, devoid of any electrodes, by electromagnetic induction, making the tube the secondary of the induction device, and passing through the primary the discharges of a Leyden jar. These tubes were made of many shapes, and I was able to obtain luminous effects which I then thought were due wholly to electromagnetic induction. But on carefully investigating the phenomena I found that the effects produced were more of an electrostatic nature. It may be attributed to this circumstance that this mode of exciting tubes is very wasteful, namely, the primary circuit being closed, the potential and, consequently, the electrostatic inductive effect is much diminished.

When an induction coil, operated as above described, is used, there is no doubt that the tubes are excited by electrostatic induction and that electromagnetic induction has little, if anything, to do with the phenomena.

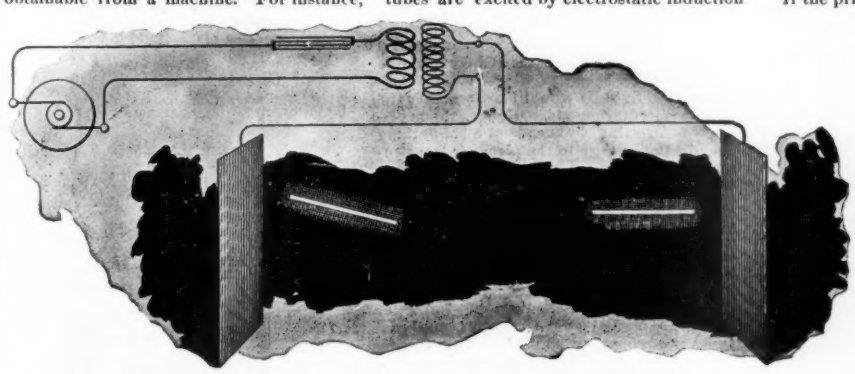


FIG. 30.—IDEAL METHOD OF LIGHTING A ROOM.—TUBES DEVOID OF ANY ELECTRODES RENDERED BRILLIANT IN AN ALTERNATING ELECTROSTATIC FIELD.

This is evident from many experiments. For instance, if a tube be taken in one hand, the observer being near the coil, it is brilliantly lighted and remains so no matter in what position it is held relatively to the observer's body. Were the action electromagnetic the tube could not be lighted when the observer's body is interposed between it and the coil, or at least its luminosity should be considerably diminished. When the tube is held exactly over the center of the coil—the latter being wound in sections and the primary placed symmetrically to the secondary—it may remain completely dark, whereas, it is rendered intensely luminous by moving it slightly to the right or left from the center of the coil. It does not light because in the middle both halves of the coil neutralize each other and the electric potential is zero. If the action were electromagnetic, the tube should light best in the plane through the center of the coil, since the electromagnetic effect there should be a maximum. When an arc is established between the terminals, the tubes and lamps in the vicinity of the coil go out, but light up again when the arc is broken on account of the rise of potential. Yet the electromagnetic effect should be practically the same in both cases.

By placing a tube at some distance from the coil, and nearer to one terminal—preferably at a point on the axis of the coil—one may light it by touching the remote terminal with an insulated body of some size or with the hand, thereby raising the potential at that terminal nearer to the tube. If the tube is shifted nearer to the coil so that it is lighted by the action of the nearer terminal, it may be made to go out by holding, on an insulated support, the end of a wire connected to the remote terminal, in the vicinity of the nearer terminal, by this means counteracting the action of the latter upon the tube. These effects are evidently electrostatic. Likewise, when a tube is placed at considerable distance from the coil, the observer may, standing upon an insulated support, between coil and tube, light the latter by approaching the hand to it; or he may even render it luminous by simply stepping between it and the coil. This would be impossible with electromagnetic induction, for the body of the observer would act as a screen.

When the coil is energized by excessively weak currents, the experimenter may, by touching one terminal of the coil with the tube, extinguish the latter, and may again light it by bringing it out of contact with the terminal and allowing a small arc to form. This is clearly due to the respective lowering and raising of the potential at that terminal. In the above experiment when the tube is lighted through a small arc it may go out when the arc is broken, because the electrostatic inductive effect alone is too weak, though the potential may be much higher; but when the arc is established the electrification of the end of the tube is much greater and it consequently lights.

If a tube is lighted by holding it near to the coil, and in the hand which is remote, by grasping the tube anywhere with the other hand, the part between the hands is rendered dark and the singular effect of wiping out the light of the tube may be produced by passing the hand quickly along the tube and at the same time withdrawing it slightly from the coil, judging properly the distance so that the tube remains dark afterward.

If the primary coil is placed sidewise, as in Fig. 17B, for instance, and an exhausted tube be introduced from the other side in the hollow space, the tube is lighted most intensely because of the increased condenser action, and in this position the striæ are most sharply defined. In all these experiments described and in many others the action is clearly electrostatic.

The effects of screening also indicate the electrostatic nature of the phenomena and show something of the nature of electrification through the air. For instance, if a tube be placed in the direction of the axis of the coil and an insulated metal plate be interposed the tube will generally increase in brilliancy, or if it be too far from the coil to light, it may even be rendered luminous by interposing an insulated metal plate. The magnitude of the effects depends to some extent on the size of the plate. But if the metal plate be connected by a wire to the ground its interposition will always make the tube go out, even if it be very near the coil. In general, the interposition of a body between the coil and tube increases or diminishes the brilliancy of the tube or its facility to light up, according to whether it increases or diminishes the electrification. When experimenting with an insulated plate, the plate should not be taken too large else it will generally produce a weakening effect by reason of its great facility for giving off energy to the surroundings.

If a tube be lighted at some distance from the coil and a plate of hard rubber or other insulating substance be interposed, the tube may be made to go out. The interposition of the dielectric in this case only slightly increases the inductive effect, but diminishes considerably the electrification through the air.

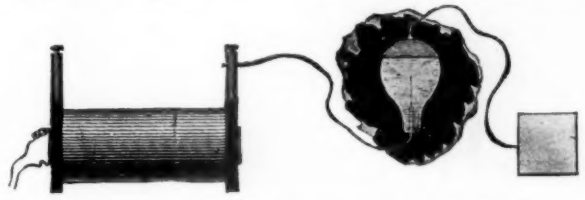


FIG. 29.—INCREASING THE BRILLIANCY OF LAMP ON ONE WIRE.

In all cases, then, when we excite luminosity in exhausted tubes by means of such a coil the effect is due to the rapidly alternating electrostatic potential; and, furthermore, it must be attributed to the harmonic alternation produced directly by the machine and not to any superimposed vibration which might be thought to exist. Such superimposed vibrations are impossible when we work with an alternate current machine.

If a spring be gradually tightened and released it does not perform independent vibra-

tions; for this a sudden release is necessary. So with the alternate currents from a dynamo machine; the medium is harmonically strained and released, this giving rise to only one kind of waves; a sudden contact or break, or a sudden giving way of the dielectric, as in the disruptive discharge of a Leyden jar, are essential for the production of superimposed waves.

In all the last described experiments, tubes devoid of any electrodes may be used, and there is no difficulty in producing by their means sufficient light to read by. The light effect is, however, considerably increased by the use of phosphorescent bodies, such as yttria, uranium glass, etc. A difficulty will be found when the phosphorescent material is used, for with these powerful effects it is carried gradually away, and it is preferable to use material in the form of a solid.

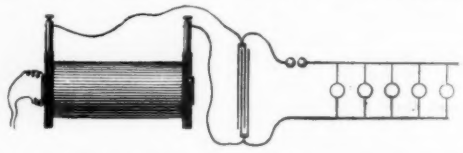


FIG. 31.—DIAGRAM OF CONNECTIONS FOR CONVERTING FROM HIGH TO LOW TENSION BY MEANS OF THE DISRUPTIVE DISCHARGE.

Instead of depending on induction at a distance to light the tube, the same may be provided with an external—and, if desired, also with an internal—condenser coating, and may then be suspended anywhere in the room from a conductor connected to one terminal of the coil, and in this manner a soft illumination may be provided.

The ideal way of lighting a hall or room would, however, be to produce such a condition in it that an illuminating device could be moved and put anywhere, and that it is lighted, no matter where it is put, and without being electrically connected to anything. I have been able to produce such a condition by creating in the room a powerful, rapidly alternating electrostatic field. For this purpose, I suspend a sheet of metal a distance from the ceiling on insulating cords, and connect it to one terminal of the induction coil, the other terminal being preferably connected to the ground. Or else, I suspend two sheets, as illustrated in Fig. 30, each sheet being connected with one of the terminals of the coil, and their size being carefully determined. An exhausted tube may then be carried in the hand anywhere between the sheets, or placed anywhere, even a certain distance beyond them; it remains always luminous.

In such an electrostatic field interesting phenomena may be observed, especially if the alternations are kept low and the potentials excessively high. In addition to the luminous phenomena mentioned, one may observe that any insulated conductor gives sparks when the hand or another object is approached to it, and the sparks may often be powerful. When a large conducting object is fastened on an insulating support and the hand approached to it a vibration, due to the rythmical motion of the air molecules, is felt and luminous streams may be perceived when the hand is held near a pointed projection. When a telephone receiver is made to touch with one or both of its terminals an insulated conductor of some size, the telephone emits a loud sound; it also emits a sound when a length of wire is attached to one or both terminals, and with very powerful fields a sound may be perceived even without any wire.

How far this principle is capable of practical application the future will tell. It might be thought that electrostatic effects are unsuited for such action at a distance. Electromagnetic inductive effects, if available for the production of light, might be thought better suited. It is true the electrostatic effects diminish nearly with the cube of the distance from the coil, whereas, the electromagnetic inductive effects diminish simply with the distance. But when we establish an electrostatic field of force the condition is very different, for then, instead of the differential effect of both the terminals, we get their conjoint effect. Besides, I would call attention to the fact that in an alternating electrostatic field a conductor, such as an exhausted tube, for instance, tends to take up most of the energy, whereas, in an electromagnetic alternating field the conductor tends to take up the least energy, the waves being reflected with but little loss. This is one reason why it is difficult to excite an exhausted tube at distance by electromagnetic induction. I have wound coils of very large diameter and of many turns of wire and connected a Geissler tube to the ends of the coil with the object of exciting the tube at distance; but even with the powerful inductive effects producible by Leyden jar discharges, the tube could not be excited unless at very small distance, although some judgment was used as to the dimensions of the coil. I have also found that even the most powerful Leyden jar discharges are capable of exciting only feeble luminous effect in a closed exhausted tube, and even these effects, upon thorough examination, I have been forced to consider of an electrostatic nature.

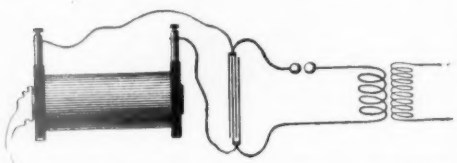


FIG. 32.—MANNER OF OPERATING AN INDUCTION COIL.

How, then, can we hope to produce the required effects at a distance by means of electromagnetic action, when even in the closest proximity to the source of disturbance, under the most advantageous conditions, we can excite but faint luminosity? It is true that when acting at a distance we have the resonance to help us out. We can connect an exhausted tube, or whatever the illuminating device may be, with an insulated system of the proper capacity, and so it may be possible to increase the effect qualitatively, and only qualitatively, for we would not get *more* energy through the device. So we may, by resonance effect, obtain the required electromotive force in an exhausted tube and excite faint luminous effects, but we cannot get enough energy to render the light practically available, and a simple calculation, based on experimental results, shows that even if all the energy which a tube would receive at a certain distance from the source would be wholly converted into light, it would hardly satisfy the practical requirements. Hence, the necessity of directing by means of a conducting circuit, the energy to the place of transformation. But in so doing we cannot very sensibly depart from present methods, and all we could do would be to improve the apparatus.

From these considerations it would seem that if this ideal way of lighting is to be rendered practicable it will be only by the use of electrostatic effects. In such a case the most powerful electrostatic inductive effects are needed; the apparatus employed must, therefore, be capable of producing high electrostatic potentials changing in value with extreme rapidity. High frequencies are especially wanted, for practical considerations make it desirable to keep down the potential. By the employment of machines, or, generally speaking, of any mechanical apparatus, but low frequencies can be reached; recourse must, therefore, be had to some other means. The discharge of a condenser affords us a means of obtaining frequencies by far higher than are obtainable mechanically, and I have accordingly employed condensers in the experiments to the above end.

When the terminals of a high tension induction coil, Fig. 31, are connected to a Leyden jar and the latter is discharging disruptively into a circuit, we may look upon the arc playing between the knobs as being a source of alternating or, generally speaking, undulating currents, and then we have to deal with the familiar system of a generator of such currents, a circuit connected to it and a condenser bridging the circuit. The condenser in such case is a veritable transformer and since the frequency is excessive, most any ratio in the strength of the currents in both the branches may be obtained. In reality the analogy is not quite complete, for in the disruptive discharge we have most generally a fundamental instantaneous variation of comparatively low frequency and a superimposed harmonic vibration, and the laws governing the flow of currents are not the same for both.

In converting in this manner, the ratio of conversion should not be too great, for the loss in the arc between the knobs increases with the square of the current, and if the jar be discharged through very thick and short conductors, with the view of obtaining a very rapid oscillation, a very considerable portion of the energy stored is lost. On the other hand, too small ratios are not practicable for many obvious reasons.

As the converted currents flow in a practically closed circuit the electrostatic effects are necessarily small, and I, therefore, convert them into currents or effects of the required character. I have effected such conversions in several ways. The preferred plan of connections is illustrated in Fig. 32. The manner of operating renders it easy to obtain by means of a small and inexpensive apparatus enormous differences of potential which have been usually obtained by means of large and expensive coils. For this it is only necessary to take an ordinary small coil, adjust it to a condenser and discharging circuit, forming the primary of an auxiliary small coil, and convert upwards. As the inductive effect of the primary currents is excessively great, the second coil need have comparatively but very few turns. By properly adjusting the elements, remarkable results may be secured.

In endeavoring to obtain the required electrostatic effects in this manner, I have, as might be expected, encountered many difficulties which I have been gradually overcoming, but at present I am not as yet prepared to dwell upon my experience in this direction.

I believe that the disruptive discharge of a condenser will play an important part in the future, for it offers vast possibilities, not only in the way of producing light in a more efficient manner and in line indicated by theory, but also in many other respects.

For years the efforts of inventors have been directed towards obtaining electrical energy from heat by means of the thermopile. It might seem invidious to remark that but few know what is the real trouble with the thermopile. It is not the inefficiency or small output — though these are great drawbacks—but the fact that the thermopile has its phylloxera, that is, that by constant use it is deteriorated, which has thus far prevented its introduction on an industrial scale. Now that all modern research seems to point with certainty to the use of electricity of excessively high tension, the question must present itself to many whether it is not possible to obtain in a practicable manner this form of energy from heat. We have been used to look upon an electrostatic machine as a plaything and somehow we couple with it the idea of the inefficient and impractical. But now we must think differently, for now we know that everywhere we have to deal with the same forces and that it is a mere question of inventing proper methods or apparatus for rendering them available.

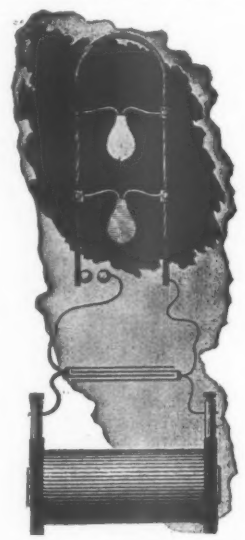


FIG. 33.—LAMP KEPT AT INCANDESCENCE ACROSS A THICK COPPER BAR—SHOWING NODES.

In the present systems of electrical distribution, the employment of the iron, with its wonderful magnetic properties, allows us to reduce considerably the size of the apparatus; but, in spite of this, it is still very cumbersome. The more we progress in the study of electric and magnetic phenomena, the more we become convinced that the present methods will be short-lived. For the production of light, at least, such heavy machinery would seem to be unnecessary. The energy required is very small, and if light can be obtained as efficiently as theoretically it appears possible, the apparatus need have but a very small output. There being a strong probability that the illuminating methods of the future will involve the use of very high potentials, it seems very desirable to perfect a contrivance capable of converting the energy of heat into energy of the requisite form. Nothing to speak of has been done towards this end, for the thought that electricity of some 50,000 or 100,000 volts pressure, or more, even if obtained, would be unavailable for practical purposes, has deterred inventors from working in this direction.

In Fig. 31 a plan of connections is shown for converting currents of high into currents of low tension by means of the disruptive discharge of a condenser. This plan has been used by me frequently for operating a few incandescent lamps required in the laboratory. Some difficulties have been encountered in the arc of the discharge, which I have been able to overcome to a great extent; besides this, and the adjustment necessary for the proper working, no other difficulties have been met with, and it was easy to operate ordinary lamps, and even motors in this manner. The line being connected to the ground, all the wires could be handled with perfect impunity, no matter how high the potential at the terminals of the condenser. In these experiments, a high tension induction coil, operated from a battery, or from an alternate current machine, was employed to charge the condenser; but the induction coil might be replaced by an apparatus of a different kind, capable of giving electricity of such high tension. In this manner direct or alternating currents may be converted, and in both cases the current impulses may be of any desired frequency. When the currents charging the condenser are of the same direction, and it is desired that the converted currents should also be of one direction, the resistance of the discharging circuit should, of course, be so chosen that there are no oscillations.

In operating devices on the above plan I have observed curious phenomena of impedance which are of interest. For instance, if a thick copper bar be bent as indicated in Fig. 33 and shunted by ordinary incandescent lamps, then by passing the discharge between the knobs the lamps may be brought to incandescence although they are short-circuited. When a large induction coil is employed it is easy to obtain nodes on the bar which are rendered evident by the different degree of brilliancy of the lamps, as shown roughly in Fig. 33. The nodes are never clearly pronounced, but there are simply maxima and minima of potential along the bar. This is probably due to the irregularity of the arc between the knobs. In general when the above described plan of conversion from high to low tension is used, the behavior of the disruptive discharge may be closely studied. The nodes may also be investigated by means of an ordinary Cardew voltmeter, which should be well insulated. Geissler tubes may also be lighted across the points of the bent bar; in this case, of course, it is better to employ smaller capacities. I have found it practicable to light up in this manner a lamp and even a Geissler tube shunted by a short heavy block of metal, and this result seems at first very curious. In fact, the thicker the copper bar in Fig. 33, the better it is for the success of the experiments as they appear more striking. When lamps with long slender filaments are used it will be often noted that the filaments are from time to time violently vibrated, the vibration being smallest on the nodal points. This vibration seems to be due to an electrostatic action between the filament and the glass of the bulb.

In some of the above experiments it is preferable to use special lamps having a straight filament, as shown in Fig. 34. When such a lamp is used a still more curious phenomenon than those described may be observed. The lamp may be placed across the copper bar and lighted, and by using somewhat larger capacities, or, in other words, smaller frequencies, or smaller impulsive impedances, the filament may be brought to any desired degree of incandescence. But when the impedance is increased, a point is reached when comparatively little current passes through the carbon and most of it through the rarefied gas; or, perhaps, it may be more correct to state that the current divides nearly evenly through both, in spite of the enormous difference in the resistance, and this would be true unless the gas and the filament behave differently. It is then noted that the whole bulb is brilliantly illuminated and the ends of the leading-in wires become incandescent and often

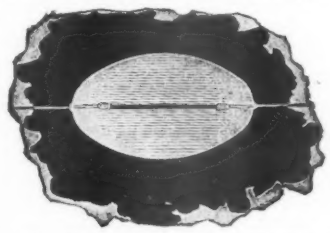


FIG. 34.—PHENOMENON OF IMPEDANCE IN AN INCANDESCENT LAMP.

throw off sparks in consequence of the violent bombardment; but the carbon filament remains dark. This is illustrated in Fig. 34. Instead of the filament a single wire extending through the whole bulb may be used, and in this case the phenomenon would seem to be still more interesting.

From the above experiment it will be evident that when ordinary lamps are operated by the converted currents, those should be preferably taken in which the platinum wires are far apart and the frequencies used should not be too great, else the discharge will occur at the ends of the filament, or in the base of the lamp between the leading-in wires, and the lamp might then be damaged.

In presenting to you these results of my investigation on the subject under consideration I have paid only a passing notice to facts upon which I could have dwelt at length, and among many observations I have selected only those which I thought most likely to interest you. The field is wide and completely unexplored, and at every step a new truth is gleaned, a novel fact observed.

How far the results here borne out are capable of practical applications will be decided in the future. As regards the production of light some results already reached are encouraging and make me confident in asserting that the practical solution of the problem lies in the direction I have endeavored to indicate. Still, whatever may be the immediate outcome of these experiments, I am hopeful that they will only prove a step to further development towards the ideal and final perfection. The possibilities which are opened by modern research are so vast that even the most reserved must feel sanguine of the future. Eminent scientists consider the problem of utilizing one kind of radiation without the others a rational one. In an apparatus designed for the production of light by conversion from any form of energy into that of light such a result can never be reached, for no matter what the process of producing the required vibrations, be it electrical, chemical or any other, it will not be possible to obtain the higher light vibrations without going through the lower heat vibrations. It is the problem of imparting to a body a certain velocity without passing through all lower velocities. But there is a possibility of obtaining energy, not only in the form of light, but motive power and energy of any other form, in some more direct way from the medium. The time will be when this will be accomplished and the time has come when one may utter such words before an enlightened audience without being considered visionary. We are whirling through the endless space with an inconceivable speed, all around us everything is spinning, everything is moving, everywhere is energy. There *must* be some way of availing ourselves of this energy more directly. Then, with the light obtained from the medium, with the power derived from it, with every form of energy obtained without effort, from the store forever inexhaustible, humanity will advance with giant strides The mere contemplation of these magnificent possibilities expands our minds, strengthens our hopes and fills our hearts with supreme delight.

GREETING.

Inasmuch as advertising is a very important factor in all lines of business, we have deemed it wise to devote a certain amount of space every week in the columns of the ELECTRICAL REVIEW to the broad discussion of this subject. It is our opinion that too little time is given to the details of this most important end of the conduct of business, hence we have been led to announce the establishing of this new feature. It is not advertising in the columns of the ELECTRICAL REVIEW, or advertising of a few individual concerns, but of advertising in its broadest sense—general advertising—that will be discussed.

We believe that there are no persons better fitted for a discussion of this subject than those who are responsible for and in charge of the advertising interests of the several concerns with whom we are all of us familiar, who are spending large sums of money every year in this department of their business. Therefore, beginning with next week, we take pleasure in announcing that space will be reserved for advertising talks, by the gentlemen referred to, who have kindly consented to send us from week to week their views on advertising, from the standpoint of actual experience.

We predict that these talks will not only be instructive, but entertaining, and we further predict that our readers will have reason to congratulate us and these gentlemen on this our new departure. Accompanying these articles will appear each week the photograph of the contributor, with his *fac-simile* autograph.

Electric Lighting of Paris.

Paris is on the eve of a revolution in her lighting system. Gas lighting was first introduced in England, but Paris followed in good time and with a splendor unequalled elsewhere. In like manner America, Germany and some other countries have been earlier in the use of electric lighting; but the Parisians, with their superior taste and skill in all matters of municipal arrangements and appointments, are destined to make by far the most brilliant use of the new illuminant. Within one year, or within two years at the farthest, it is confidentially claimed that Paris will be incomparably the best lighted city in the world, and that electricity will have superseded gas in public use.

In 1878, at the time of the universal exposition, the municipal government ordered the experimental illumination of the Avenue de l'Opera and several open spaces with electricity. The great electrical improvements of the past decade were exhibited in the French exposition of 1889, and were studied with the utmost care by the Parisian authorities and municipal engineers. Undoubtedly the displays at the exposition had the most pronounced effect in stimulating the new zeal Paris is showing for the appliances of the electric age.

The manner in which Paris is now proceeding to introduce electricity in every portion of the municipal area is of the utmost importance to all other cities that have to do with similar problems. There has been no undue haste. On the contrary, the subject has been treated in a patient, scientific, systematic way. To begin with, the municipality has spent 2,000,000 francs or more in making a central electrical installation of its own in the basement of "Les Halles Centrales," the great central market of Paris. This plant is conveniently situated for the illumination of a number of public buildings and establishments, and it can be enlarged indefinitely.

But it has never been intended to use this or any other municipal installation for the general work of lighting the city. It is for experimental purposes, and also for the purpose of acting as a regulator of charges. It enables the municipality to command the situation, and gives it a corps of men who understand the practical details of an electrical establishment.

For the purpose of general illumination the city has been divided into seven "secieurs electriques." Paris is approximately a circle, and the secieurs are segments, the dividing lines of which radiate from the vicinity of the Halles as a center and extend to the circumference. Each of these secieurs has been granted exclusively for a short term of years to a responsible electric company.

Thus Edison has been accorded one, the great Paris contractor, Victor Popp, using the Thomson-Houston system, has two and the others are conceded, respectively, to the Messrs. Rothschild, the Societie Alsacienne, the Ferranti Company, of London, and Naze & Company, representing the Westinghouse system. Several of the secieurs were granted in the latter part of 1890, completing the distribution. As one of the conditions it has been required that the companies proceed at once to make their installations, and that within two years their districts shall be completely served with main cables.

Thus, before the end of 1892, such provision will have been made that, if desired, every street in Paris, as well as every house, can be illumined with electricity. It is required that the companies shall supply street lighting upon terms that are as favorable as possible—at cost or even less—and a maximum rate of charge to private users is prescribed. Each company has been required to give a guaranty fund of several hundred thousand francs to insure the fulfillment of all the conditions imposed in the concession. No payment has been required for the charters, the terms being short, and permanent arrangements being deferred until use can be made of the results of five or ten years' experience. Meanwhile the city has its own central plant, and it is not debarred from laying its cables into any or all of the secieurs, with a view to regulating prices by competition. Thus Paris is on the point of being more completely supplied with electric lighting facilities than any other large city in the world.

It should be noted that the question how to dispose of wires—a question that makes so vast and so continually recurring an agitation in all American cities—never comes up at all in Paris, and is seldom mentioned in any European city. There are absolutely no obstructive wires in Paris. The government has purchased the telephone as well as the telegraph system, and all the wires for these services are placed in the subways of sewers. The wires of the electric companies are buried under the sidewalks. Armored cables are laid in simple conduits, or even in the bare soil, without the slightest difficulty from any point of view. In crossing streets it is forbidden to break the paving, and underground connection is made from the manholes of the sewers.

The whole city of Paris will have been laid with a network of electric lighting cables a few months hence, and traffic on the sidewalks and in the streets will have suffered a minimum of obstruction, while no injury whatsoever will have been done to pavements. All these minor questions of practical municipal engineering that we in our cities are attacking in a fumbling, rude, original way, heedless even of the experience of our nearest neighbors, while densely and contentedly ignorant of the experience of foreign cities, have been thoroughly solved in Europe.

Instead of leading the van, we are from 10 to 15 years behind Europe in all these matters.

Even in our own field of electrical methods, as a prominent American electrician assured me in Paris last December, we are now five years behind the Continent. He declared that the difficulties our American corporations still complain about, when asked to bury their telegraph, telephone and lighting wires, were all met and vanquished in Europe several years ago, and that our fellow countrymen insist upon remaining in a state of invincible ignorance rather than learn anything from the technical and scientific achievements of Europe.

But perhaps he stated the case too strongly. Doubtless we shall learn in time to be ashamed when we come to a realizing sense of the fact that the one city of Paris has at its command a larger and more brilliant array of engineering and architectural talent than all the important cities of the United States taken together can show, and that many a small European town is better supplied in this respect than many a large American city.—*The Century for July.*

ELECTRIC POWER NOTES.

* * The Edison system will be used on the electric railway at McKeesport, Pa.

* * There is talk of connecting Goshen and Elkhart, Ind., by an electric railway.

* * Edison motors and Brill cars will be used on the electric railway at Du Bois, Pa.

* * The mule has gone; the electric line is a success and Houston is happy.—*Houston, Tex., Post.*

* * The People's Railway Company, of Syracuse, N. Y., has been granted a franchise to operate all the lines there by electricity.

* * It is proposed to build an electric railway from Santa Barbara, Cal., through Montecello to the Hot Springs. The distance is something over six miles, and the estimated cost $80,500.

* * The new Harvard bridge across the Charles River, at Boston, is to be equipped with a Thomson-Houston motor for operating the draw. Current will be furnished by the Brookline Gas Company.

* * An electric road between St. Louis and Clayton, Mo., the county seat, seems now a certainty, and accordingly there is rejoicing among the property owners along the proposed route who refused the low figures offered them for their holdings by the promoters of the enterprise, and are now assured of higher prices.

* * An electric railway to connect Fall River, Mass., with Seaconnet and Compton, R. I., is contemplated. The route is about 16 miles long, and it is quite probable that the Globe Street Railway Company, of Fall River, which is to run its cars by electricity, will extend its tracks from the present terminus, near the shawl mills, to the Riverton depot. If this is done, a passenger can go from the City Hall, in Fall River, to the Seaconnet House, a distance of 24 miles.

* * The loss sustained by the Newburyport & Amesbury, Mass., Street Railway Company by the burning of its stables and carhouse, June 27, will reach $40,000. The rolling stock destroyed includes four cars equipped with motors and 12 cars which were without motors. Notwithstanding the crippled condition of the road, it made all trips on time the next day. The company will at once erect a substantial brick carhouse.

ELECTRIC LIGHT NEWS

—— The Woonsocket R. I. Electric Light Co. is building an addition to its plant.

—— Automatic sprinklers last week extinguished a small fire at the plant of the Fort Wayne Electric Company.

—— The Gloucester, Mass., Electric Company have increased their capital $50,000, and propose to extend their business.

—— The recent fire at the Bay County Electric Light Company's plant, at Bay City, Mich., caused a loss of $50,000. Insurance, $10,000.

—— The city counsel has set aside the 8th day of July for a special meeting to consider applications for franchises from all electric light and electric railway companies that desire to establish plants or build lines in the city of Brownwood, Tex.

—— An Edinburgh man has invented an ingenious electromagnet gas controller which will automatically turn up the gas when the electric light is turned off, and in case the electric light is turned on again the gas will at once be lowered.

—— Judge Lawrence has dissolved the injunction obtained by the United Electric Power Company to prevent the city of New York from compelling the company to take down its aerial wires. The city will remove the wires, it is said, if the company doesn't put them into the subways.

—— It has been decided to light by electricity the workshops and yards of the Intercolonial Railway, at Moncton, N. B. The managers of the Intercolonial have adopted the "Wood" system of arc lighting, and have given the contract for the same to Mr. A. J. Corriveau.

—— Ten cables of the Wilmington, Del., electric light system and of the police alarm telegraph system, were broken by the steam dredge "Vim" last week. The cables were caught by the dredge bucket in its descent to the bottom of the creek, and were broken in attempting to lift it out of the water.

—— An incandescent lamp, the invention of a French army officer, is placed at the end of a brass tube, blackened on the inside, with a mirror set in it at an angle of 45°, so that it will reflect up through the tube the light of the electric lamp below, which is thrown against the walls of the projectile or cannon which it is desirable to examine.

Another Pole War.

An electric light pole war is going on at Beloit, Wis. A day or two ago Mr. Salmon felled a pole in front of the post office, and afterward had to call on the police to protect his property from the Electric Light Company who had a gang of men on the ground to again erect the pole. Both parties have had injunctions served on them. Marshal North and Mr. Salmon have been arrested for destroying the pole. The police are guarding the property and the electric light men are on hand ready to begin operations when the officials retire.

The European Welding Company.

The affairs of the Thomson European Electric Welding Company are in a most satisfactory condition. It has completed its arrangements with the English company, and whether the contract with the latter is fulfilled or not, it will be a gainer, as a non-fulfillment on the part of the London people would leave about $400,000 of option money in the hands of the American company. The prospects are very favorable for a speedy sale of its patents on the continent, and it is likely to derive great benefit from a company about to be started in England for the manufacture of projectiles. The latter industry will necessitate the use of the machines of the Welding Company. The new company is expected to be brought out between July 1 and July 15.—*Boston Beacon.*

KINDRED INTERESTS

The Emerson Electric Manufacturing Company, St. Louis, Mo., have sent out a convincing little pamphlet, telling all about the merits of the Weston alternating fan motor.

The Clark Electric Company, 192 Broadway, New York, is sending out circulars, telling of the advantages of the Clark system. The safety device used by this company fully protects from danger due to broken wires.

The Eureka Tempered Copper Company, North East, Pa., report that notwithstanding the general dullness of trade their plant is running on full time, and that they are 60 days behind their orders already booked.

The Jos. Dixon Crucible Company's card calendar for July appropriately illustrates the struggles of a Brownie with the implements of torture incident to the Glorious Fourth. The sky rockets are made of Dixon's pencils, and the smile of cherubic joy which lights up the Brownie's face—and the fireworks—indicates that "they go."

The Burton electric heaters, for which the Electric Merchandise Company, of Chicago, are the sole selling agents, are in use on the following street railways and on trial on a number of others: Marlborough, Mass., Lynn, Mass., St. Louis, Mo., Joplin, Mo., Hannibal, Mo., Merrill, Mo., Springfield, Ill., Newark, N. J., Richmond, Va., Terre Haute, Ind., Salt Lake City, Utah, and North Attleboro, Mass.

The Central Electric Company, Chicago, are showing some very handsome samples of lead encased Okonite cable. The demand for this class of cable has increased so lately that the Okonite Company have decided to go into its manufacture on a large scale, and are selling their product in the West through the above company, who are their general Western agents. They have already received some flattering contracts, and will soon be in the field as active competitors for this class of work. They are also prepared to lay the cable, and deliver it connected up, ready for current, having especially good facilities for performing these contracts.

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Engine Lathes, 10 in. x 4 ft.; 11 in. x 5 ft.; 12 in. x 6 ft.; 14 in. x 6 ft.; 16 in. x 6 ft.; 18 in. x 8 ft.; 20 in. x 8 ft., with tapes attachment; 22 in. x 12 ft. and 14 ft.; 24 in. and 26 in. x 16 ft.; 30 in. x 10 ft. and 18 ft.; 36 in. and 38 in. x 20 ft.; 42 in. x 12 ft.; 56 in. x 18 ft.; 72 in. x 20 ft.; 108 in. x 22 ft. Fox Lathes, 13 in. x 5 ft.; 14 in. x 5 ft.; 15 in. x 6 ft.; 18 in. x 6 ft. Turret Lathes, 12 in. x 5 ft.; 14 in. x 5 ft.; 15 in. and 16 in. x 6 ft.; 18 in. x 6 ft.; 36 in. x 8 ft.
Planers, 16 in. x 16 in. x 3 ft.; 20 in. x 20 in. x 4 ft.; 24 in. x 24 in. x 6 ft.; 30 in. x 30 in. x 6 ft.; 36 in. x 36 in. x 10 ft.; 42 in. x 42 in. x 12 ft.; 72 in. x 60 in. x 15 ft.; 72 in. x 60 in. x 20 ft.
Friction Shapers, 15 in., 16 in., 20 in., 22 in., 32 in.
Crank Shapers, 6 in., 8 in., 10 in., 12 in., 15 in., 16 in., 20 in., 24 in., 28 in.
Screw Machines, Nos. 1, 2, 3, 4, with or without Wire Feed.
Screw Machines, Nos. 5, 6, 7, 8, Power Feed.
Presses, Nos. 51, 52, 53, Ferracute, Nos. 1, 2, 3, Stiles & Parker.
20 Lincoln Pattern Millers, No. 2.
Hand Millers, Nos. 1 and 2. 3 Cam Cutters.
Bolt Cutters, ¼ in. to 1 in., ½ in. to 2 in.
2 Profiling Machines. 1 36 in. and 48 in. Gear Cutter.
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ELECTRICAL PATENTS

INDEX OF INVENTIONS FOR WHICH LETTERS PATENTS OF THE UNITED STATES WERE ISSUED ON JUNE 30, 1891.

454,867 Electrical transmission of telegraphic and time indications; Henry J. Haight, New York, N. Y.

454,873 Carbon for electric arc lamps; Washington H. Lawrence, Cleveland, O.

454,881 Overhead electric conductor system. 454,882 Electro-dynamic machine. 454,883 Motor generator or transformer; Gordon J. Scott, Minneapolis, Minn., assignor of one-half to Calvin G. Goodrich, same place.

454,884 Printing telegraph instrument; Frederick Sedgwick, Chicago, Ill.

454,888 Electric car motor jacket; John Stephenson, New York, N. Y.

454,890 Apparatus for removing inductive effects from electric lines; Elihu Thomson, Lynn, Mass., assignor to the Thomson-Houston Electric Co. of Connecticut.

454,897 Time lock; George W. Adams, Malden, Mass.

454,903 Means for connecting trolley and feed wires; John R. Fletcher, Chicago, Ill.

454,904 Aerial cut-out; John R. Fletcher, Dayton, O.

454,924 Hotel indicator; Frank B. Wood, New York, N. Y., assignor to Theodore W. Bayaud, same place.

454,925 Process of manufacturing gas; William G. Wood, Windsor, Canada, assignor of three-fourths to Thomas A. Bourke, John A. Smith, Charles H. Delisle and John McArdle, all of same place; Charles F. Conrad, administrator of said Wood, deceased.

454,926 Protector for use in electric circuits; William H. Clausen, Melrose, assignor to Joseph W. Larish, trustee, Boston, Mass.

454,938 Method of laying electric conduits. 454,939 Means for constructing electric conduits; Alexander C. Chenoweth, New York, N. Y.

454,941 Phonograph recorder or reproducer. 444,942 Phonograph; Thomas A. Edison, Llewellyn Park, N. J.

454,947 Reproducer for phonographs; William McMahon, Rahway, N. J.

454,949 Electric meter; Herbert M. Pilkington and Roger S. White, Brooklyn, N. Y.

454,969 Electric current regulator or rheostat; Charles D. Sigsbee, U. S. Navy, and Thomas S. Hayward and Frank S. Anderson, Easton, Md.; said Anderson and Hayward assignors, by direct and mesne assignments, to said Sigsbee.

454,973 Electric signaling apparatus. 454,974 Circuit for electric signaling; Morris Martin, Malden, assignor to Frederick P. Fish, Cambridge, Mass.

454,979 Electric heater; Charles W. Drew and Edward R. Francis, Minneapolis, Minn.; said Francis assignor to said Drew.

454,985 Electric temperature controller; Emer H. Parker, Evanston, Ill.

454,995 Electric switch; James Des Brisay, New York, N. Y.

455,005 Circuit closer for burglar alarms; Don A. Palmer, Chicago, Ill.

455,010 Electric soldering iron; Arthur E. Appleyard, Boston, assignor to Henry L. Millis, trustee, Millis, Mass.

455,016 Electrical annunciator; William F. Harte and Clifford A. Gerold, Omaha, Neb.; said Gerold assignor to said Harte.

455,019 Circuit connection for electric car motors; Arnold A. Ingraham, New York, N. Y.

455,037 Apparatus for boring wells; Fulton Gardner, Chicago, Ill., assignor to himself and A. M. Butz, same place.

455,038 Pneumatic fire alarm telegraph apparatus; Albert Goldstein, Baltimore, Md.

455,041 Electric clock for use in electric lighting and other systems; Friedrich von Hefner-Alteneck, Berlin, Germany.

455,055 Electric time denoting device; William Ramsay, Washington, D. C.

455,067 Electro-magnetic motor. 454,068 Electrical meter. 455,069 Electrical incandescent lamp; Nikola Tesla, New York, N. Y.

455,071 Clutch for arc lamps; Frank H. Thompson, Philadelphia, Pa., assignor of one-half to Daniel Killion, same place.

455,073 Printing telegraph; Henry Van Hoevenbergh, New York, N. Y., assignor to the Equitable Manufacturing and Electric Co., same place.

455,087 Electric arc lamp; Craig R. Arnold, Chester, Pa.

455,092 Automatic electric clutch; Carl O. C. Billberg and Paul A. N. Winaud, Philadelphia, Pa.

455,107 Insulator. 455,233 455,234 Electric railway; James F. Munsie, Brooklyn, N. Y.

455,109 455,110 Electric motor; Frederick L. McGahan, Indianapolis, Ind.

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